



UNIVERSITY OF CALIFORNIA  
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W.P. Hiern Esq. Rush J. P.  
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THE  
GENUS DIOSPYROS IN CEYLON:  
ITS MORPHOLOGY,  
ANATOMY, AND TAXONOMY.  
**PART I.**

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By HERBERT WRIGHT.

[Reprinted from "Annals of the Royal Botanic Gardens, Peradeniya,"  
Volume II., Part I., January, 1904.]

ADDED TO VOLUME  
PAGE 131 OF 201A

*See Journ. Bot. 1904, pp. 100-102 (June 1).*

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# The Genus *Diospyros* in Ceylon: its Morphology, Anatomy, and Taxonomy.

BY

HERBERT WRIGHT.

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## Part I.

THE original portion of this paper deals exclusively with the genus *Diospyros*, *L.*, as represented in Ceylon by some twenty species, of which Trimen remarks: "Very little is known about many of our species, which are rare or local in the forests of the wet region and seem to flower but seldom. The native Sinhalese names are vaguely applied or very local, and refer more to the wood than to the trees themselves; and one is rarely able to obtain both wood and herbarium specimens from the same tree, in which way alone it is possible to be justified in definitely deciding the source of the former. The various rare mottled cabinet-woods, which appear to be produced only by very old trees, and are known as calamander (*kalu-mediriya*, *wal-mediriya*, *ho-mediriya*, &c.), have mostly yet to be referred to their respective species." In view of this lack of definite knowledge and the commercial value of ebony, calamander, and other timbers, the present investigation, which has occupied much time during the last three years, both in the forests and in the laboratory, was undertaken.

The present contribution is divided into two parts, the first part containing a general statement of, and a discussion on, the various subjects investigated; the second part a detailed

[Annals of the Royal Botanic Gardens, Peradeniya, Vol. II., Pt. I., January, 1904.]

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description of each species. In Part I. the following arrangement has been adopted:—

- I.—History. *Mh. 2 - 11.*
- II.—Distribution in Ceylon. *Mh. 11 - 14.*
- III.—Vegetative Characters. *Mh. 14 - 21.*
- IV.—Anatomy; Timber Properties, &c. *Mh. 21 - 55.*
- V.—Seedlings. *Mh. 55 - 67.*
- VI.—Reproductive Organs. *Mh. 67 - 105.*
- VII.—Affinity. *Mh. 105, 106.*

### I.—HISTORY. *Mh. 2 - 11.*

Diospyros is the largest and most important genus of the Ebenaceæ, and since most papers dealing with this order contain a description of many of our species, it is necessary to trace the history of the literature on the whole subject to gain a better grasp of the general bearing of the particular species with which we are concerned.

The accumulation of knowledge regarding the Ebenaceæ has not been rapid, probably on account of the difficulty of obtaining representative material of a natural order so widely spread, and also in virtue of the comparatively unattractive nature of this group of plants. Though in 1753 Linnæus published the names of a few species, no work of a representative kind was published until that of Hiern in 1873. During that interval the work consisted mainly of collecting and describing species, remarking on fossil forms and affinities, and discussing the ebony yielded by this group of plants.

It was not until the latter part of the nineteenth century that any internal characters were used for systematic purposes, but since that time the majority of contributions have dealt extensively with the internal or microscopical construction of the vegetative parts. The only lines of study which have hitherto been neglected are those connected with the development and anatomy of the embryos and seedlings.

In 1753 Linnæus\* described five species of the Ebenaceæ, two of which belonged to the genus Diospyros. New species and genera were subsequently described by Linnæus,† C. Linnæus,‡ and Loureiro,§ and others were figured and described by Roxburgh|| and König in 1795. It was not until 1799 that the natural order Ebenaceæ was established by Ventenat;¶ subsequently it received considerable attention, many species and genera being quickly added from Mauritius by Poiret,\*\* from Australia by Brown,†† from Java by Blume, from India by Wallich,‡‡ and from the Philippines by Blanco.§§

The Ebenaceæ of Ventenat, revised by Jussieu,||| had by this time greatly enlarged, and the necessity for a further revision was obvious; accordingly, G. Don¶¶ undertook this work and gave a description of every species known to him.

This was speedily followed by more collecting, and finally A. de Candolle\*\*\* wrote a monograph on the whole of the Ebenaceæ. Having formed some definite ideas as to the external morphology of the Ebenaceæ, many botanists of that period turned their attention to the possible affinities of the order, and in 1845 we have the first fossil species described by Braun, and subsequent contributions on fossil species by Unger, Ettingshausen, Zollinger, and others.

The phylogeny of the order was discussed by Miers††† and Choisy,‡‡‡ the former proposing that the Ebenaceæ be

\* Linnæus, Species Plantarum, 1753.

† Linnæus, 13th Edition of Systema, 1774.

‡ C. Linnæus in Supp. Spec. Plt., 1781.

§ Loureiro, Flora Cochinchinensis, 1790.

|| Roxburgh, Coromandel Plants, 1795-1819.

¶ Ventenat, Tableau du Regne Végétal, 1799.

\*\* Poiret, Encyclopédie méthodique, 1804.

†† Brown, Prodomus floræ novæ Hollandiæ, 1810.

‡‡ Wallich, East Indian Plants, 1828, 32.

§§ Blanco, Flora de Filipinos, 1837.

||| Jussieu, Ann. du Muséum, Vol. V., 1804.

¶¶ G. Don, General System of Gardening and Botany, Vol. IV., 1837.

\*\*\* Alph. de Candolle, Prodr. Syst. Nat. Regni Veget., Vol. VIII., 1844.

††† Miers, Contributions to Botany, Vol. I., p. 24, 1851.

‡‡‡ Choisy, Memoires des Ternstroemiaceæ, p. 9, 1855.

regarded as a polypetalous group allied to the Anonaceæ, and the latter contending that they showed strong affinities to the Ternstroëmiaceæ.

The technical value of the timber had also gained a high reputation, and many botanists discussed the origin of the term "ebony," Bertolini\* contending that the ebony of the ancients was not furnished by the Ebenaceæ.

From the time of publication of the monograph by A. de Candolle in 1844 up to 1873 no work of great systematic importance was produced. In the meantime several species had been described or figured by Wight (1850), Dalzell (1852), Martins and Miguel (1856), Thwaites (1854-64), Beddome and Kurz (1871), Mueller and Bentham (1864-9), Oliver (1868-77), Eichler (1870-80), Bentham and Hooker *Gen. Hist.* (1872-3), and Grisebach in 1872. These, together with short accounts of the fossils, affinity, and the timbers, were all that appeared in the thirty years subsequent to the monograph by A. de Candolle.

In 1873, however, Hiern† published his monograph, which is without question the most comprehensive work on the subject. This work is purely systematic, and deals with the characters of the floral and vegetative members, the distribution of the species, their probable affinity, and the several uses to which the parts of certain species are put. Hiern distinguishes five genera, two being endemic in Africa (Royena and Euclea), one (Tetraclis) in Madagascar, and the others (Maba and Diospyros) represented in many parts of the world. The genus Diospyros, as described by Hiern, contains 160 species, and is therefore by far the most important in the order. With it Hiern has united the genera Cargillia, *R. Br.*; Leucoxylum, *Blume*; Noltia, *Schum.*; and Gunisanthus and Rospidios, *DC.* The second largest genus—Maba—includes Macreightia, *A. DC.*, and Rhipidostigma, *Dalz.* The three remaining genera contain a total of

\* Bertolini, *Miscellanea Botanica*, XII., 1849.

† W. P. Hiern, *A Monograph of Ebenaceæ*, *Trans. Camb. Phil. Soc. Cambridge*, 1873.



thirty-three species, and since they are not represented in the flora of Ceylon, they need not be considered here.

The Brazilian genus *Brachynema*, *Benth.*, and the Javanese *Drebbelia*, *Zoll.*, are regarded by Hiern and others as being non-Ebenaceous, and as probably of Olacinaceous affinity.

The five genera recognized by Hiern are so closely associated with one another that many botanists have suggested the advisability of uniting all into one genus.

Hiern bases his classification of the genera mainly on the sex of the flowers, having the genus *Royena* with hermaphrodite or rarely subdioecious flowers; the remaining genera, including *Diospyros*, with dioecious or rarely polygamous flowers. The observations were made upon material from the recognized herbaria of Europe, and a small quantity of spirit material obtained from Dr. Thwaites, Ceylon.

As will be shown later, the sex of the Ceylon species of *Diospyros* has been imperfectly and often erroneously described as a consequence of examining only herbarium specimens instead of the fresh material in the jungle.

The effect of Hiern's admirable monograph is well seen if one considers the history of the development of our knowledge prior and subsequent to its publication. Since 1873 but little has been contributed to our systematic knowledge of the Ebenaceæ, and from that time the anatomists have been at work on the basis laid down in Hiern's monograph. Their investigations have resulted in more definite knowledge regarding the structure of the leaves, the secondary tissues of the stem, and the nature of the causes leading to the discolouration of the timbers.

Wiesner\* described the internal characters of the stems of some Ceylon species of *Diospyros*, and gave details of an onerous method of preparing sections of ebony, which was subsequently adopted by Molisch. His work was succeeded by contributions from Moeller,† in which the anatomy of

\* Wiesner, *Ebenholz*, 1870.

† Moeller, *Holz anat.*, in *Denkschr. Wiener Akad.*, 1870-3.

the axis was more thoroughly dealt with, and a theory was set forth explaining the enhanced durability of ebony as a consequence of the walls of the elements being impregnated with a colouring substance of unknown chemical constitution.

See Hartig p. 21.

A much more instructive paper was then issued by Molisch,\* who prepared his sections by the method of Wiesner. Molisch described the anatomy of the stem of two of our species, *D. Ebenum*, *Koen.*, and *D. sylvatica*, *Roxb.*, together with three others, and a species from each of the genera *Maba*, *Euclea*, and *Royena*. He attempted to combine the facts of internal construction with external morphology, believing with Radlkofer that this would provide the best basis for a systematic grouping of the plants. He also laid stress on the striking anatomical resemblances of the species he examined, and endeavoured to discover whether the reason of the high technical value of the ebony woods lay in the anatomical construction or in the chemical changes going on within the tissues.

In connection with the colouring matter of the timbers, he believed that the initial deposits were true gums, and that the suspected resin was a product of a slow process of humification going on within the elements. He further endeavoured to show that seasonal rings of growth were found in the secondary xylem of trees of *D. Virginiana*, *L.*, which had been grown in Europe, whereas those grown in the tropics showed no such histological differentiation. The various points raised by Molisch will be subsequently discussed under their respective sections in the present contribution.

Hartig† has given an account of the timber of several species, and has discussed the views of Moeller and Molisch as to the nature of the colouring substance in ebony. He

\* H. Molisch, Vergleichende Anat. des Holzes der Ebenaceen und ihrer Verwandten. Sitz. Akad. Wiss. zu Wien, Bd. 80, Abth. 1, 1879.

† Hartig, Bot. Ztg., p. 108, 1859, and also Lehrbuch für Förster, I. Theil, p. 256, 1861.

believed that the coloured body filling the lumina of the secondary xylem elements was neither a gum nor a resin, but one of unknown and singular chemical composition. This subject was then taken up by Belohonbek\* and Höhnel,† the former concluding, after a detailed chemical analysis, that the black contents of the timber, soluble in alkali, were mainly humus acids, and the remaining material, insoluble in alkali, more or less pure carbon.

Moeller made another contribution at about the same time dealing with the anatomy of the bark, and the origin layer of the phellogen. Solereder‡ also made additions to our knowledge on the same subject, and described the histological details of the secondary elements and the papillæ on the under surface of the leaves of many species. Radlkofer§ discussed the value of internal characters, and stated that in the Ebenaceæ the affinity so apparent in the flowers may be reflected in the anatomical construction of the vegetative parts. In the same year Weiss|| and Gürke¶ published works on the Ebenaceæ; the former dealing with the nature and origin layer of the phellogen and its products, and the latter discussing the leading anatomical and morphological characters as known to him.

In 1892 the last anatomical contributions to our knowledge of the Ebenaceæ were made by Pomrencke\*\* and Parmentier,†† the former dealing comparatively with the timbers, and the latter giving a detailed account of the anatomy of the vegetative members of very many species. The contribution

\* Belohonbek, Ebenholz, in Sitzb. K. böhm. Gesellsch. d. Wiss in Prag., 1883.

† Höhnel, Stockwerkart Holz., in Sitzb. Wiener Akad., Bd. LXXXIX., Abs. 1, p. 42, 1884.

‡ Solereder, Holzstruktur, 1885, pp. 68-169.

§ Radlkofer, Durchs. P. in Sitzb., Münch. Akad., 1886, p. 323.

|| Weiss, Korkbild., in Denkschr. Regensb. bot. Gesellsch., 1890, p. 57.

¶ Gürke, in Nat. Pfl., IV. Theil, Abth. 1, 1890.

\*\* Pomrencke, Holz. enig. symp. Fam. in Arb. bot. Gart. Breslau, 1892, p. 49-51.

†† Parmentier, Histologie comparée des Ebénacées, Paris, 1892. 155 figs., 4 pls.

by Parmentier contains a general discussion of the anatomical and morphological characters of the genera, and a detailed description of the anatomy of the leaves of seventy species of *Diospyros* and of other fifty species belonging to the remaining genera. Several complicated and ingenious tables are given, intended to show the relationships of the species of each genus to one another, the conclusions being based on the work of Hiern and the anatomists previously mentioned. Analytical tables for the genera and species are constructed on the sex characters of the flowers as determined by Hiern, together with the pericyclic or sub-epidermal origin of the phellogen in the stem. Parmentier believes that the genus *Diospyros* is characterized by a sub-epidermal phellogen in the stem, and on this ground, since *D. oppositifolia*, *Thw.*, and *D. suberifolia*, *Dcne.*, have a pericyclic phellogen, he transfers them to the genus *Euclea*.

Such a position is untenable, and it is unwise to lay down such rigid classifications from observations on only 40 per cent. of the species of *Diospyros*; furthermore, the sex of one of the species, viz., *D. oppositifolia*, *Thw.*, was not then known, and though it was regarded as being dioecious, I have since been able to prove that it is monoecious only. The classification put forward is further weakened by the discoveries regarding the true nature of the sex of *Diospyros*, and the behaviour of the phellogen in the pericycle and cortex of the primary axis.

The detailed accounts of the parts of the leaf and the grouping of species of *Diospyros* according to the subcentric or bifacial mesophyll, the immersion or projection of the median and lateral traces, and similar leading characters are particularly instructive, though we cannot but regard the tables of affinity, such as that on pages 56-57, as being premature, seeing that our knowledge of the whole order was then, and still is, meagre and unreliable.

We have seen that from 1873 the main work has been on the anatomy of the stem and leaves and the origin layer of

the phellogen. Smaller papers appeared during that period from Hiern\* on new species and from Naudin† on the general natural history of the cultivated forms. Contributions of systematic significance were issued by Kurz‡ and Vesque,§ the latter working on the lines of Parmentier and pointing out many epidermal characters of specific importance.

The timbers also received the attention of Brandis,|| and in more recent times were studied by Broun¶ and Ursprung.\*\* The last-named botanist has compiled some very instructive information regarding the seasonal histological differentiation in the secondary xylem of tropical grown trees, including several Ceylon *Diospyros* species.

There has been only one publication dealing extensively with the Ebenaceæ during the present century, this being a purely systematic work by Hallier†† in 1901. Hallier deals with the relationships of the Tubifloræ and the Ebenales in a very general way, and from considerations upon the morphology of the flowers, fruits, and seeds, together with the phyllotaxis of the members concerned, he builds up a complicated table intended to show the polyphyletic origin of the sympetalous and apetalous flowering plants. He contends that the Ebenales show a close relationship with the Anonaceæ, Scytopetalum, Geraniaceæ, Dipterocarpaceæ, Sapotaceæ, and makes suggestive remarks as to their possible affinity to the Ancistrocladeæ, Convolvulaceæ, Quinaceæ, and many other natural orders. The contribution is full of

\* Hiern, notes on Ebenaceæ, Jour. of Bot., XII., XIII., XV., 1874, 75, 77.

† Naudin, Quelques remarques au sujet des Plaqueminiers cultivés à l'air libre dans les jardins de l'Europe; in Nouv. archiv. du Mus. d'hist. nat., Paris, 1880.

‡ Kurz, Flora of British Burma, 1874-7.

§ Vesque, Gamopétales in Ann. Sc. nat., Ser. 7, 1885.

|| Sir D. Brandis, Conf. Ind. Timbers, Col. Exh., 1886.

¶ A. F. Broun, Ceylon Ebony, Indian Forester, July, 1899.

\*\* A. Ursprung, Beiträge zur Anatomie und Jahresringbildung tropischer Holzarten; Inaug. Dissert. Hohen. Phil. Fac.; Basel, 1900.

†† Hallier, Über die Verwandtschaftsverhältnisse der Tubifloren und Ebenalen, den polyphyletischen Ursprung der Sympetalen und Apetalen und die Anordnung der Angiospermen überhaupt. Hamburg, 1901.

interesting suggestions, and convinces one that there is no finality in pointing out the morphological resemblances between widely separated families. There is no difficulty in tracing a particular character of a floral or vegetative member through numerous non-related natural orders; in some orders the character is presented in a suppressed or enhanced form, and to deduce affinity therefrom inevitably leads to a confused notion as to the true significance of the feature dealt with.

The subject, as dealt with by Hallier, is very complicated, and in the end one gains very little precise information as to the phylogeny of any group of Angiosperms with which he has dealt.

*Local History.*—In connection with the history of our knowledge of Ceylon species, twenty in number, there are several interesting facts to record.

Though some of the species of *Diospyros* occurring in Ceylon are to be found in Malaya, Burma, Tropical Australia, Peninsular India, Anamalai hills, Tinnevely, and South India generally, there are several endemic forms.

*D. Ebenum*, *Koenig*,\* was the first species found in Ceylon, in 1776, but it has since been discovered in many parts of Southern India and in Malaya. It is the chief source of ebony in Ceylon, and the high commercial value of the timber was probably the reason of its being the first species to be recognized. It was not until five years later that the next species was discovered, *D. hirsuta*, *L.*,† an endemic form very common in the wet low-country.

In 1795 Roxburgh‡ discovered on the Coromandel Coast three species which were subsequently found wild in this Island, viz., *D. Melanoxylon*, *Roxb.*, the source of most of the Indian ebony, but nearly extinct in Ceylon; *D. montana*, *Roxb.*, a species abundant in the low forests of the

\* Koenig, in *Phys. Salsk. Handl.*, Vol. I., p. 176, 1776.

† Linnaeus, *Suppl. Plant.*, p. 440, 1871.

‡ Dr. Roxburgh, *Coromandel Plants*, Vol. I., pp. 36, 37, 38, t. 46, 48, 47, 1795.

hot dry country in Ceylon; and D. sylvatica, Roxb., now only rarely met with in this Island. In 1807 D. Embryopteris, Pers.,\* and in 1827 D. Toposia, Ham.,† were found, the former first in the East Indies and the latter in Bengal, but both subsequently found in very many parts of Ceylon. Nearly a quarter of a century passed before the next Ceylon species was found, and this discovery—D. ovalifolia, Wight‡—was first made in Madras. This was speedily followed by the discovery of D. pruriens, Dalz.,§ first in Bombay by Dalzell, and subsequently in the Sabaragamuwa Province by Thwaites.¶ By that time Dr. Thwaites, then Director of the Royal Botanic Gardens, Peradeniya, had commenced the work of collecting the plants of Ceylon, and his discovery of D. pruriens, Dalz., in Ceylon, so soon after that by Dalzell, was followed by the discovery of ten¶ species of Diospyros in 1860; seven of these have not yet been found out of Ceylon, and some of them are at the present time exceedingly rare. The species found were:—

1. D. crumenata, D. affinis, D. quæsitæ, D. oocarpa, D. insignis,  
 4. D. oppositifolia, D. Gardneri, D. Moonii, D. acuta, and D.  
 7. attenuata. Since then only one species has been added to the Ceylon group, viz., D. Thwaitesii, by Beddome\*\* in 1871, a form peculiar to this Island.

Locally, no further original work has been done on the genus Diospyros other than what is represented in Dr.

Trimen's "Handbook of the Flora of Ceylon." *Bat. cf. D. opaca C.B. Cl. in Hort. f. 86. Brit. Ind. III. p. 587 (1882).*

## II.—DISTRIBUTION IN CEYLON. *M. 11-16.*

The forest vegetation in Ceylon varies according to the rainfall and elevation, and as far as the genus Diospyros is concerned we may speak of the species as being dry, wet,

\* C. H. Persoon, Synopsis Plantarum, Vol. II., p. 624, 1807.

† Hamilton, Trans. Linn. Soc., Lond., Vol. XV., p. 115, 1827.

‡ Dr. Wight, Icones Plant. Ind. Orient., t. 1, 227, 1850.

§ Dalzell, Kew Journal of Botany, Vol. IV., p. 110, 1852.

¶ Trimen, Flora of Ceylon, Vol. III., p. 95.

¶ Thwaites, Enum. Plant. Zeyl., pp. 179-182, 1860.

\*\* Beddome, Ic. Pl. Ind. Or., p. 27, t. cxxxv., 1871.

or intermediate zone plants. In the dry zone, where the rainfall ranges from 35 to 70 inches, we have seven species, viz., D. Ebenum, D. Embryopteris, D. Melanoxylon, D. oocarpa, D. montana, D. affinis, and D. ovalifolia. The majority of these species, particularly D. Ebenum, D. ovalifolia, and D. Embryopteris, are to be found in abundance in local areas of the dry zone. D. oocarpa is less common, though at Mihintale, Dambulla, Haragama, Maturata, and Kalugala it is abundant in many of the forests. Of the dry zone species D. Melanoxylon has the most limited distribution. It was first found by Dr. Trimen\* between Bibile and Ekiriyanakumbura in 1888, and the fact that its existence was not determined by Dr. Thwaites is sufficient to show its rarity. In 1901 its presence was again noted in this locality, and in addition a large number of plants were found on the patana and in the coarse forests at Elukapudena and Diggallana to the south-west of Bibile. Many large trees were also found along the roadside from Bibile to Bintenna, and in the forest along the side and at the base of Bibile hill.

cf. p. 19. The remaining thirteen species occur in the wet zones, where the rainfall is never less than 80 inches, and in places often reaches over 300 inches per annum, and at elevations from sea level to 4,000 feet. The most generally distributed species are D. insignis and D. Toposia. In the districts around Ratnapura, Sinha Raja forest, Pasdun korale, and Hiniduma, the species D. hirsuta, D. Moonii, and Thwaitesii are specially abundant. In the higher parts of the wet zones, as at Ambalawa, Hantane, Kadugannawa, and Gangaruwa, abundance of D. crumenata, D. Gardneri, and D. sylvatica is met with. The remaining species are rare, and occur in the low-lying wet forests of the Southern and Western Provinces.

The rarest of the wet zone species is undoubtedly D. oppositifolia. Specimens of this species were collected at Hiniduma in 1853 by Dr. Thwaites, and this was the only material which Dr. Trimen ever saw. This species is

\* Flora of Ceylon, Vol. III., p. 99.



limited to the upper part of Hinidunkanda, a hill in the Southern Province some 2,200 feet high. The upper part of this hill is for the greater part of the year enveloped in clouds, and it is only between 1,500 and 2,000 feet that this species occurs. It is particularly abundant, together with D. quæsita, on the north-west flank, and is entirely absent from the eastern part of the hill. The species D. acuta and D. attenuata are the next in point of rarity, they being limited to the low wet country between Hinidunkanda and Pitigala. Both species occur in abundance in the damp forests of Wewella, Pasdun korale, and D. acuta extends to the Wirakanda forests near Hewessa.

The remaining wet zone species—D. pruriens and D. quæsita—occur in the wet forests of Karawita, Sinha Raja, Hiniduma, and Yagirala. D. pruriens reaches its maximum dimensions and is most abundant in the forests of the Adam's Peak Wilderness, and thrives best on the rocky soils in the vicinity of Magala, Kadawatta, and Eratna, where the rainfall is very heavy.

In the intermediate zones, where the rainfall varies from 70 to 80 inches, the whole of the dry zone species, excepting D. Melanoxylon, occur, but of the wet zone species, however, only two—D. Gardneri and D. sylvatica—occur.

### **Intermingling of Dry and Wet Zone Species.**

One rarely meets with any of the thirteen species of the wet zone in a purely dry zone. D. Moonii, a species possessing relatively thick fleshy leaves, is reported from dry places along the coast, though it is most characteristic of districts where the rainfall is great. Again, D. insignis, a species generally distributed in the wet zone, occurs in the Pindeniya and Kegalla districts. None of the wet zone species have ever been reported from the arid zones of the Island.

On the other hand, at least two of the dry zone species—D. Ebenum and D. Embryopteris—constantly recur in

truly wet zones. These two species, though attaining their maximum distribution in the dry areas around Anuradhapura, Trincomalee, Vavuniya, &c., may also be found in the low-lying forests of Sabaragamuwa and the Central Province, sometimes being very plentiful along the banks of streams. In the moist regions D. Ebenum may extend up to 4,000 feet, many occurring at Hantane, Ambalawa, Gangaruwa, Hinidunkanda, Borulugoda, Eratna, and Hewessa. The dimensions of trees of these two species when in the wet zone are usually but not always less than those from a dry zone. Specimens of D. montana, D. oocarpa, D. ovalifolia, or D. affinis have not yet been recorded from any wet zone area, though D. oocarpa is known in the intermediate zone.

### III.—VEGETATIVE CHARACTERS. *pp 14-21.*

*Dimensions, Habit, &c.*—As far as the Ceylon representatives of the genus *Diospyros* are concerned, every species assumes an arborescent habit.

It is characteristic of the dry zone species to attain huge dimensions. D. Ebenum, being the main source of ebony in the Island, is usually felled after attaining a breast-height circumference of 6 feet, but further increments are possible, and many trees are known with a circumference of 9 to 10 feet. Specimens of D. affinis in the Viriniya and Bibile districts and of D. Embryopteris at Anuradhapura often attain a circumference of 9 feet and possess an unbranched bole over 50 feet in length. The total height of the dry zone species is often over 100 feet, and the huge dimensions are only departed from when the plant occurs in the wet zone areas.

There is, however, one district in the wet zone where trees of D. Ebenum and D. Embryopteris attain dimensions which outrival those known in the dry zones. I refer to the Ambalawa district on the boundary between the Central and Sabaragamuwa Provinces, where the rainfall is over 100 inches a year and the elevation varies from 2,000 to 3,500

feet. Here there is one specimen of D. Embryopteris measuring no less than  $16\frac{1}{2}$  feet in circumference, not allowing for the undulations in outline, which, if taken into account, would give a total circumference of over 20 feet and a height of 130 feet. Specimens of D. Ebenum also occur in the same forest which have a circumference of nearly 13 feet and a total height of 100 feet.

With the wet zone species there is likewise a wide range of variability, though only few species attain the huge dimensions of the dry zone plants.

Among the smallest trees we may place D. pruriens, since in the Sinha Raja district a single plant is often of convenient size for a herbarium sheet. This species, when it attains its maximum dimensions along the rocky slopes of the Peak Wilderness, rarely exceeds a total height of 9 metres (30 feet) and a circumference of 30.5 cm. (12 inches).

In point of size, D. acuta and D. attenuata come next to D. pruriens. In the wet forests of Pasdun korale these species occur in the form of small trees, from 20 to 30 feet in height and 1 to 4 inches in diameter. The leaders have often a weeping habit, particularly in D. attenuata, and though only 1 inch in diameter, may bear abundance of flowers and fruits. One specimen of D. attenuata was obtained in flower in the Wewella forest which had a short straggling leader only 14.0 cm. in diameter. Trees of these species frequently occur in groups of three to fourteen trunks matted together by dense woody roots at the common base of the trunks, and this, together with the weeping habit, is suggestive of the bamboo clumps growing in the same area. cf p. 17.

D. hirsuta, though occurring so abundantly along the streams around Ratnapura, Eratna, and Hiniduma, rarely exceeds 9 metres (30 feet) in height and 20 cm. (8 inches) in diameter. When the stem is only 7.5 to 10.2 cm. (3 to 4 inches) in diameter the plant bears fertile seeds.

D. Thwaitesii, except in the Hiniduma district, is a tree similar in size to D. hirsuta, and in the Hewessa and Palakete

forests rarely exceeds a total height of 30 feet and a diameter of 5 inches. In the Hiniduma district, however, particularly along the north-west side at an elevation of 1,000 feet, many specimens of D. Thwaitesii attain a total height of 15.2 to 18.3 metres (50 to 60 feet) and a breast-height circumference of 50 to 76 cm. (20 to 30 inches).

D. insignis, characterized by its straight leader unbranched to a height of 6.1 metres (20 feet), is likewise of comparatively small dimensions. The breast-height circumference rarely exceeds 64 cm. (25 inches), and many plants having a main stem less than 12.7 cm. (5 inches) diameter bear a considerable amount of fruit.

The above-mentioned species may be regarded as those in the wet zone, which are characteristically of small dimensions. Commencing with the class possessing species of relatively large dimensions, we may for the sake of a continuous series first consider the smaller members, D. Moonii and D. oppositifolia, which thrive best along the banks of streams or along damp precipitous slopes, and usually attain a total height of 12.2 to 18.3 metres (40 to 60 feet) and a breast-height circumference of 610 to 915 mm. (2 to 5 feet). Nevertheless, specimens of D. Moonii in the Hewessa district and D. oppositifolia on the western side of Hinidunkanda occur as clumps of thin leaders matted together at the base by a common system of roots.

Next to these we may place D. quæsitæ, D. Toposia, and D. Gardneri, since they often attain a total height of 30.5 metres (100 feet), and many exceed a breast-height girth of 1.8 metres (6 feet).

The remaining wet zone species, D. crumenata and D. sylvatica, may attain dimensions which rival the colossal species of the dry zone. The largest specimen of D. sylvatica in Ceylon is probably at Ambalawa, near Gampola, since it consists of a main stem 4.2 metres (13½ feet) in circumference which remains unbranched for a distance of 24.4 metres (80 feet). At this height the stem branches, one fork then

continuing its upward course through a distance of over 30·5 metres (100 feet). In the Ambalawa and Dambalagalla districts there are some very fine patches of forest in which trees of *Diospyros* species are very abundant and attain huge dimensions.

*Branch System.*—The branch system is invariably well developed. Though the conditions of canopy do to a very great extent determine whether the branches shall grow erect, horizontal, or assume a weeping habit, yet it seems characteristic of certain species to possess branch systems of a fixed type. For instance, under conditions of open or close canopy, *i.e.*, either exposed equally on all sides or in dense forest, trees of *D. Embryopteris* have a branch system usually nearly horizontal. Again, *D. quæsitæ* has a branch system spreading at an angle of  $40^{\circ}$  to  $50^{\circ}$  and according to Hiern the branch system of *D. sylvatica* spreads at  $60^{\circ}$  to  $70^{\circ}$ . Specimens of *D. attenuata* growing in dense forest have invariably a weeping habit, though the weight of foliage, &c., is never great. cf. p. 15.

*Phyllotaxy.*—In the majority of the Ceylon species the alternate arrangement of the leaves is characteristic on twigs of the mature plant. Small shoots of *D. Moonii* have often large leaves arranged alternately along the length of the thin stem. The final disposition of the mature leaves is usually one which ensures the maximum of light on their upper surfaces, and many leaves in their attempts to attain this position have undergone much twisting, particularly in the region of the petiole. There are, however, three of our species in which the phyllotaxy departs from the alternate type.

The leaves of *D. Melanoxydon* are usually opposite; sometimes they are sub-opposite and occasionally alternate. In very many instances the leaves are densely crowded, either at the end of a twig or near the main stem. *D. insignis* has the majority of its leaves disposed alternately

and the remainder sub-opposite. D. oppositifolia resembles D. Melanoxylon in the opposite and sub-opposite arrangement of the leaves. In the former species, however, many twigs have their leaves crowded together to form large rosettes.

*Form and Size of Leaves.*—The leaves conform to the usual tropical type in that they are simple, entire, and petiolate. The shape may be ovate (D. ovalifolia), lanceolate (D. hirsuta), or lanceolate oblong, with a tapering or abrupt apex, and a rounded or tapering base.

The size varies considerably, being smallest (30 to 70 mm.) in D. oocarpa and D. pruriens, and largest (190 to 350 mm. long) in D. Moonii, D. insignis, and D. Embryopteris. Within the same species there is often a considerable variation in size, the young leaves arising on offshoots from the main stem being many times the size of those occurring on the normal twigs. A case in point is in the large leaves of D. Melanoxylon, these occurring on the young shoots arising from the base of small trees and measuring 100 to 240 mm., whereas the normal dimensions for this species are 50 to 100 mm. Heterophylly occurs to a marked degree in D. Gardneri, D. oppositifolia, and D. sylvatica.

*Venation.*—The vascular bundles in the leaf form a central stout midrib with several smaller lateral factors connected alternately along its length, these in their turn being made up by the coalescence of the very small bundles scattered between them. Sometimes the vascular bundles project strongly on the upper surface (D. Embryopteris), sometimes on the lower surface (D. insignis), but are often relatively inconspicuous (D. affinis, D. montana, and D. oocarpa).

The midrib may be very conspicuous, as in D. Moonii and D. acuta, or it may be insignificant as in D. oocarpa and D. attenuata.

The lateral and reticulate bundles are invariably pellucid ; sometimes this character is not very conspicuous, as in D. affinis ; in other species, particularly D. Embryopteris, D. Ebenum, and D. Toposia, the translucent character of the small bundles is the most striking feature of the foliage.

The reticulate meshwork is of a closely knit nature in D. Toposia ; and in D. Embryopteris, particularly var. nervosa, the meshwork is wide.

The pellucid venation, though characteristic of every Ceylon species of Diospyros, is not limited to this group of plants. It is prominent throughout the Anonaceæ, and also characterizes the foliage in species of Anacardium.

*Climatic Types.*—The majority of the Ceylon species have tough coriaceous leaves, this being particularly characteristic of D. insignis, D. Embryopteris, and D. Ebenum. The coriaceous type of leaf is prevalent in nearly every one of our dry zone species. In the wet zone species we may have the fleshy type of leaf, as in D. acuta and D. Moonii ; the densely pubescent and thin type, as in D. pruriens ; or the normal tender leaves, as in D. attenuata and D. Thwaitesii. The fleshy type and the densely pubescent type are, as far as the Ceylon species of Diospyros are concerned, limited to the very wet zone. The pubescent type, as exemplified in the leaves of D. pruriens, is found in a part of the Island where the rainfall is never less than 300 inches per year ; D. hirsuta, which in point of pubescence comes next to D. pruriens, likewise thrives best in the wet districts of Eratna and Ratnapura. 06/12.

*Persistence of Foliage.*—The Ceylon species of Diospyros are of the evergreen type. This is characteristic of the genus throughout the world, there being very few exceptions, notably D. Tupru, Buch., which according to Beddome sheds all its leaves in the cold season and produces new ones in the beginning of the hot weather. The twigs of D.

montana and D. ovalifolia become partially leafless every year in the dry northern districts of Ceylon.

In Ceylon the leaves of most species of *Diospyros* drop at irregular intervals, and if one tree be selected for observation there is hardly a week passes without a shedding of a few leaves. The leaf-fall in most species is not sufficient to render the tree even partially bare, and the nett result of the leaf production, which repeatedly occurs, is an increase of foliage from year to year. The production of new leaves takes place during nearly every month of the year, if one considers the whole of the *Diospyros* species in the Island. If, however, one selects a district where the force of each monsoon and the intervening lulls is felt, a regularity in the leaf production is noticeable.

In the Peradeniya district there is an annual production of leaf in flowering trees of D. Gardneri, D. Embryopteris, D. Ebenum, D. affinis, D. Toposia, D. sylvatica, and D. crumenata. In non-flowering trees of D. Embryopteris there is a production of new leaf twice yearly, this occurring during the months of April to June and October to November.

The production of new leaf on any particular tree may be completed within one month, or new foliage may appear for several months in succession. The prolonged period of active growth occurs in one tree of D. Toposia from December to June, and again in trees of D. Ebenum leaf production may commence in December and continue for four or five months. Other trees of D. Toposia and D. Ebenum in the same and also adjacent districts may not produce any new leaves until well on in the months of February and March.

Respecting other species of *Diospyros*, particularly D. hirsuta and D. Thwaitesii in the wet zone, I have never visited the forests without finding some trees in new leaf during nearly every month of the year.

In the wet zone it is impossible to speak of any month as being specially noticeable for leaf production within the



*Diospyros* genus. The leaf production is apparently not of such a nature as to severely tax the resources of the plant, and its occurrence is probably to be correlated with individual requirements rather than with climatic conditions.

This can only obtain in the vegetation of the tropics where the temperature and rainfall are relatively equable throughout the year.

#### IV.—ANATOMY, TIMBER, &c. *pp. 21-55.*

*Stem.*—In the genus *Diospyros* the phellogen is often said to be of sub-epidermal origin, and this is considered by Parmentier and Solereder to be of taxonomic importance, the former using this as one of the main characters in his proposed grouping of the genera. The phellogen, however, actually arises either immediately beneath the epidermis or from the pericycle, the latter origin being conspicuous in the primary axis or hypocotyl of the seedlings.

The sclerotic or stone cells of the cortex are conspicuous in *D. Ebenum*, and the various stages of their formation and degeneration are shown. (See pl. XIX., figs. 1-4); they are relatively short, thick walled, and well pitted; finally they lose their definite outline and form hyaline masses of tissue, which do not respond to the commoner staining reagents. In longitudinal section they are seen to be surrounded with parenchyma and long sclerenchymatous fibres. The phloëm and cambium are of the ordinary type, and we may proceed to deal with the anatomy of the secondary xylem.

The observations of Molisch, Möller, Solereder, and Parmentier, already referred to, all agree as to the regular composition of the secondary xylem, the scarcity of tracheids, and the distribution of the elements. *ante pp 6, 7.*

Molisch obtained his sections of the hard brittle ebony by the method of Wiesner, which is briefly as follows: A thin slip of ebony, 2 to 3 cm. square, is cut by a fret-saw and fastened by means of sealing wax to a cork; both sides of the section are then polished on a smooth rotating wheel, *p. 50.*

and when sufficiently thin the section is removed and finally polished on a razor stone. This method allows one to obtain fairly large sections, though smaller sections cut by hand in the ordinary way provide ample material for obtaining all points in detail.

*Histology of the Timbers.*—The anatomy of the secondary xylem of the Ceylon species of *Diospyros* is of the ordinary arborescent dicotyledonous type. The differentiation of the tracheal elements and fibres is remarkably uniform, but the parenchymatous tissues exhibit sufficient variation to allow of a grouping of the various species under different types. In dealing with the distribution, size, form, and percentage number of the secondary xylem elements one must allow for variability even for members of the same species, since they may have developed under quite dissimilar climates and their internal requirements are probably at great variance. As far as possible the statements have been made in a general sense, and where it has been possible to obtain material of the same species in the dry, wet, and intermediate zones, this has been done.

### Tracheal Elements.

The tracheal elements are almost wholly represented by vessels; tracheids are never abundant, and when present usually occur alongside a large vessel.

*Vessels.*—The distribution of these elements varies according to the species, the age of the secondary xylem, and the climatic conditions under which the plants have grown. Usually the vessels occur in a more grouped condition in the xylem of the first few years than in the sapwood of old trees.

In some species the heartwood appears to be characterized by an equal number of isolated vessels and radial groups of two or three cells. Usually the members of vessels, when occurring in groups, form rows two to four cells in radial thickness; in others, notably *D. attenuata*, the groups may contain twenty members arranged one to two cells in

tangential width. Sometimes one group is separated from its neighbour only by a single line of medullary ray cells; usually, however, there is a wide band of fibres and parenchyma between parallel rows of vessels.

There does not therefore appear to be much regularity in the distribution of the vessels in the secondary xylem, and one may find as many as eight radial groups in one field, while adjacent parts of the same section may not show a single vessel, though the field of view is 0.6 mm. in radius. Usually, in passing from within outwards the vessels become more widely separated, tend to be more as single members, and are considerably increased in size.

In the sapwood of D. Moonii the vessels are nearer to one another tangentially than in the heartwood, yet in other species the space between the vessels increases from within outwards.

They are usually surrounded with fibres or flanked with short wood parenchyma or medullary ray.

The size of the members is never very great. The transverse and longitudinal dimensions show a regular increase as one passes from the heartwood to the sapwood, and it may be taken for granted that the larger the dimensions of the trunk the larger will be the dimensions of the vessels in the youngest part of the sapwood. This regular increase occurs in all our species, and is probably correlated with the physiology of the plant, particularly the storing and conducting of water. This increase of dimensions in the products of the old cambium is not characteristic of all the secondary xylem elements, and with the vessels we have to note that the increase of dimensions is concomitant with a decrease in percentage number and a more complete isolation from like elements. The fact that there is in every case a decrease in the percentage number when there is the maximum amount of foliage, and therefore probably maximum transpiration, renders some increase in size absolutely necessary when the heartwood is blocked up with gum and resin.

## Dimensions of Vessels.

[Tw. = twig ; Sw. = sapwood.]

		Diameter. mm.		Radial Dia- meter. mm.		Tangential Diameter. mm.		Length. mm.
D. Ebenum	...	{ Tw. 6	...	0.045	...	0.034	...	0.31
		{ Sw. 360	...	0.085	...	0.081	...	0.45
D. quæsitâ	...	{ Tw. 15	...	0.04	...	0.04	...	0.22
		{ Sw. 190	...	0.13	...	0.07	...	0.43
D. oocarpa	...	{ Tw. 23	...	0.027	...	0.025	...	0.23
		{ Sw. 255	...	0.07	...	0.06	...	0.42
D. affinis	...	{ Tw. 9	...	0.03	...	0.03	...	0.22
		{ Sw. 200	...	0.12	...	0.08	...	0.45
D. montana	...	{ Tw. 8	...	0.04	...	0.07	...	0.34
		{ Sw. 175	...	0.07	...	0.05	...	0.36
D. Embryopteris	...	{ Tw. 9	...	0.04	...	0.04	...	0.31
		{ Sw. 360	...	0.14	...	0.09	...	0.43
D. Moonii	...	{ Tw. 15	...	0.06	...	0.05	...	0.27
		{ Sw. 165	...	0.18	...	0.10	...	0.35
D. attenuata	...	{ Tw. 6	...	0.025	...	0.028	...	0.21
		{ Sw. 140	...	0.09	...	0.06	...	0.32
D. pruriens	...	{ Tw. 9	...	0.038	...	0.04	...	0.26
		{ Sw. 80	...	0.11	...	0.10	...	0.44
D. acuta	...	{ Tw. 7	...	0.034	...	0.028	...	0.31
		{ Sw. 60	...	0.10	...	0.09	...	0.50
D. hirsuta	...	{ Tw. 10	...	0.03	...	0.026	...	0.41
		{ Sw. 75	...	0.18	...	0.09	...	0.45
D. Thwaitesii	...	{ Tw. 11	...	0.027	...	0.02	...	0.30
		{ Sw. 203	...	0.14	...	0.09	...	0.42
D. crumenata	...	{ Tw. 20	...	0.05	...	0.04	...	0.27
		{ Sw. 210	...	0.16	...	0.10	...	0.54
D. sylvatica	...	{ Tw. 9	...	0.03	...	0.028	...	0.20
		{ Sw. 405	...	0.13	...	0.09	...	0.36
D. Gardneri	...	{ Tw. 14	...	0.05	...	0.045	...	0.30
		{ Sw. 170	...	0.09	...	0.06	...	0.46
D. oppositifolia	...	{ Tw. 11	...	0.03	...	0.026	...	0.32
		{ Sw. 170	...	0.14	...	0.09	...	0.4-0.6
D. Melanoxylon	...	{ Tw. 10	...	0.023	...	0.03	...	0.36
		{ Sw. 270	...	0.13	...	0.09	...	0.46
D. ovalifolia	...	{ Tw. 22	...	0.024	...	0.024	...	0.20
		{ Sw. 240	...	0.05	...	0.05	...	0.40
D. Toposia	...	{ Tw. 14	...	0.027	...	0.03	...	0.27
		{ Sw. 250	...	0.09	...	0.05	...	0.30
D. insignis	...	{ Tw. 12	...	0.03	...	0.034	...	0.21
		{ Sw. 185	...	0.11	...	0.073	...	0.42

The dimensions of the vessels in the heartwood vary to a slight extent ; in the first three or four years' wood the radial diameter varies from 0.024 to 0.05 mm., the tangential diameter from 0.024 to 0.06 mm., and the length from 0.20 to 0.35 mm.

In the sapwood of the whole of our species the variation in radial diameter is from 0.05 to 0.18 mm., and the variation in

length of the members of the vessels from 0.30 to 0.54 mm. This constancy in size throughout the genus in Ceylon is one of the main characters of the timbers. When one considers the climatic differences between Mannar and Adam's Peak Wilderness, one is led to expect that there will be great differences in the size of the water storing and conducting tissues in the species growing at these places, but such differences are by no means pronounced.

There is very little variation in the form of the members of vessels. In the heartwood the small-lumined vessels are, when isolated, approximately spherical or crudely hexagonal in transverse outline, but as one passes to the sapwood the increase in dimensions is more in the radial than the tangential direction, and as a consequence a radially elongated element presents itself. When the members are grouped, however, the spherical or elongated outline is rarely met with, one or more sides become straight, and the tangential diameter of each member is usually considerably more than the radial.

The sides of each member are characterized by a straight vertical course, and the original transverse partitions are only slightly inclined to the horizontal.

The walls of the vessels vary in thickness from 0.002 to 0.0035 mm. They are usually very well pitted. They are composed mainly of lignin, which continues to respond to the safranin and fuchsin tests even when considerably discoloured, and the lumina partially filled with coloured materials.

The function is probably that of storing or even conducting water, but when once the lumina are filled with gum and resin this function must be taken up by the younger tracheal elements. The vessels do not undergo depletion of coloured contents, the infiltrating materials increasing from time to time until the vessels are completely blocked.

*Tracheids.*—There is not very much to be said about these elements. They are only very sparsely distributed, and in

transverse sections only differ from the vessels in being usually of smaller diameter. They are generally limited to the neighbourhood of large vessels, frequently flanking the tangential surface, but in *D. Embryopteris* they may occasionally be seen among fibres.

The transverse dimensions are often only a trifle in excess of the largest wood parenchyma cells, but in some instances they attain a radial diameter of 0.04 to 0.08 mm. In length they come next to the fibres and may attain 0.27 to 0.90 mm. When of great length the ends taper very strongly, and in such cases it is difficult to distinguish them from the more abundant fibres, and the term "fibre-tracheids" would be very appropriate. The commonly small and constant transverse dimensions of true fibres seems to differentiate them from tracheids, but otherwise it often becomes well nigh impossible to distinguish a short fibre from a narrow lumined, long tracheid.

### **Parenchymatous Elements.**

This includes the wood parenchyma, fibres, and medullary rays of the secondary xylem. It is in the distribution of these elements that the maximum variation occurs, and even in our Ceylon species it is sufficient to allow of a grouping of the species into sections according to—

- (1) Whether the medullary rays are one cell in tangential breadth.
- (2) Whether the medullary rays are more than one cell in tangential breadth.
- (3) The presence of special radial groups of parenchyma.

As with the tracheal elements, the general features of distribution, histology, and function may be subject to all manner of variation according to the internal and external forces at work.

The parenchymatous tissues compose the greater part of the secondary xylem and increase considerably with the age of the cambium. It is obvious that the value of the timber

is greatly due to the percentage composition of elements of the parenchyma type and the structure and form of these elements.

In the poorer timbers the wood parenchyma is usually of the thin walled, wide lumined type, and this alone is often responsible for the inferior quality, for no matter how thick and long the surrounding fibres may be, the soft bands of parenchyma, when present, lead to early cracking and decay.

*Wood Parenchyma.*—In transverse sections the presence of these elements is usually determined by the abundance of carbohydrate and mineral contents, together with their relatively thin walls and wide lumina. Often, however, they are not easily distinguishable, sometimes because their transverse dimensions are similar to those of the neighbouring cells, as in *D. quærita*; sometimes on account of the proximity of adjacent medullary rays, and again because the surrounding fibres may not have undergone much lignification; the latter is often the case in the secondary xylem of young twigs. In some species they are always very conspicuous, either on account of their lumina being very large, or because adjacent medullary rays are separated by patches of fibre of considerable tangential width.

The difficulty of distinguishing these elements, however, is only when one is limited to transverse sections; the great length of these elements and their numerous contents serve to isolate them in any longitudinal section.

The distribution of these elements is somewhat complex, and is such that a continuous system of elements of the parenchyma type is established, together with frequent direct and indirect contact with the tracheal elements. The wood parenchyma cells are distributed as tangential bands, oblique bands, and around large tracheal elements. The tangential bands usually extend from one medullary ray to another, and their significance varies according to the width of this gap; the tangential bands between adjacent rays in xylem of

the same age are connected by the intervening parenchymatous medullary ray cell, and a fairly continuous circumferential circulation of food materials can therefore be effected through such elements. In a few cases, however, the tangential line of parenchyma only reaches half way from one ray, the terminal cell appearing in transverse section to be surrounded by unlike elements; it is conceivable that there may be some connection in the vertical course.

In the majority of our species the tangential lines of parenchyma are only one cell in radial thickness; in some species, notably *D. affinis* they are very often two, and are occasionally grouped in the middle of a patch of fibres. In some specimens of *D. hirsuta* the bands—two cells in radial thickness—often run together through a vertical distance of over 0.8 mm. These tangential bands of wood parenchyma are separated from one another radially by patches of fibres from 0.06 to 0.18 mm. in thickness. These elements are therefore in communication with like elements or those of the medullary ray by means of their radial surfaces, with fibres by their tangential surfaces, and with tracheal elements by any surface.

The oblique bands of wood parenchyma are obvious in many species, and it is very probable that if sufficient material were examined they would be found to occur in all species.

The components of these bands, instead of being arranged to form one line parallel to the circumference, are arranged in radial series, one slightly internal to the next, and thus result in what may be described as a terraced system of parenchyma. Adjacent cells are usually in contact with one another by a part of their radial surfaces, and the terracing is therefore very gradual. Such systems of parenchyma connect one medullary ray to the next, but it is obvious that they tend to bring into direct communication the successive tangential bands between the same medullary rays, and therefore to establish a more thorough communication between like elements in tissues of different ages.



In some specimens of D. montana from Trincomalee I observed that some oblique bands of wood parenchyma were connected at the outer end to the median cells of a tangential band of parenchyma, and within, to a medullary ray at a point opposite to another tangential line of parenchyma. By this means tangential bands of one zone can be connected, almost directly, with a band in an older zone, along a different radius. Such an arrangement must greatly facilitate the transference of food materials through the parenchymatous system.

The tangential and oblique bands of wood parenchyma therefore effect an excellent communication with all elements, excepting perhaps the vessels and tracheids. The remaining part of the wood parenchyma is, however, specially associated with these elements. In most of our species the large vessels are surrounded or flanked on their tangential surfaces with relatively wide lumined but short wood-parenchyma cells. These are in communication with the other cells of wood parenchyma or medullary rays, and therefore a complete communication is effected with every element of the secondary xylem.

The vertical distribution of these elements is easy to follow since they are arranged one above another through a considerable vertical distance. They form very long columns of cells, often as many as twelve cells in the same row. The majority form single straight lines with the components exactly above one another; frequently one cell abuts on to another, not end to end, but by the radial walls, thus giving the terraced system in the vertical direction.

There is nothing unusual in the form of these elements. In transverse outline they may be any shape from circular to crudely four-sided, but only rarely do they exhibit sharp corners. They are elongated considerably in the vertical direction, the vertical walls being straight and the end walls flat or occasionally tapering at one end when in contact

with unlike elements. When one end tapers the appearance is very similar to that of a short fibre.

There is a little variation in the transverse, but considerable in vertical dimensions throughout the species. In some species the relatively large transverse dimensions aid materially in distinguishing them in the wood of young twigs.

The following are the dimensions of these elements in the sapwood of the respective species :—

Species.	Radial Diameter. mm.			Length. mm.
<i>D. Ebenum</i>	...	0.015	...	0.03 to 0.12
<i>D. quæsitæ</i>	...	0.009	...	0.04 to 0.15
<i>D. oocarpa</i>	...	0.013	...	0.06 to 0.13
<i>D. affinis</i>	...	0.016	...	0.09
<i>D. montana</i>	...	0.02	...	0.07 to 0.20
<i>D. Embryopteris</i>	...	0.01	...	0.09 to 0.13
<i>D. Moonii</i>	...	0.015	...	0.08 to 0.20
<i>D. attenuata</i>	...	0.014	...	0.08 to 0.18
<i>D. pruriens</i>	...	0.015	...	0.08 to 0.14
<i>D. acuta</i>	...	0.013	...	0.09 to 0.15
<i>D. hirsuta</i>	...	0.018	...	0.05 to 0.13
<i>D. Thwaitesii</i>	...	0.013	...	0.05 to 0.18
<i>D. crumenata</i>	...	0.016	...	0.06 to 0.12
<i>D. sylvatica</i>	...	0.014	...	0.07 to 0.20
<i>D. Gardneri</i>	...	0.016	...	0.07 to 0.18
<i>D. oppositifolia</i>	...	0.014	...	0.08 to 0.13
<i>D. Melanoxylon</i>	...	0.017	...	0.07 to 0.13
<i>D. ovalifolia</i>	...	0.011	...	0.09 to 0.13
<i>D. Toposia</i>	...	0.013	...	0.06 to 0.15
<i>D. insignis</i>	...	0.014	...	0.06 to 0.19

The thickness of the wall varies from 0.001 to 0.0016 mm. These are the average radial dimensions and variations length of the wood parenchyma cells in the sapwood of the several species. The age of the trees and the climates under which they have grown are widely different, though the above does not show any remarkable variation.

*Wood Fibres.*—These compose the greater part of the secondary xylem, and are responsible to a great extent for the durability of the timber. The occurrence in large numbers of these elements of great length, with thick walls and narrow lumina, enhances the value of any timber.

These elements form large patches of tissue, often entirely filling the gap between adjacent medullary rays; at other times scattered with intervening wood parenchyma. In the heartwood the fibres form much larger and more compact areas, in radial and tangential thickness. In the sapwood one meets with relatively narrow bands of fibres, often only a single radial line of fibres existing between adjacent medullary rays.

In their vertical distribution one notes the wavy outline of individual fibres and the deviation from the vertical of their tapering ends.

The fibres are mainly in contact with like elements, or with those of the wood parenchyma on their tangential surfaces and medullary ray cells on their radial surfaces; they are rarely in direct contact with vessels, since the latter are usually surrounded by short parenchyma cells.

There is nothing remarkable in their form; they possess the normal thick or thin walls, small transverse dimensions, great vertical length, and strongly pointed ends.

The transverse outline is usually strikingly angular, and the lumina may be only partially or almost completely closed by the secondary thickening of the walls. As previously mentioned, the vertical outline is often wavy and deviates considerably from the vertical near the tapering ends.

The constancy in transverse dimensions is exhibited in these elements better than in any others; the maximum variation is however seen in the length of these elements, since they vary from that of a cambium cell to over 1 mm. in length. The thickness of the wall varies from 0.001 to 0.003 mm.

The range of variation in transverse dimensions as one passes from the heartwood to the sapwood in very old trees is very small, and this relative constancy allows one to readily distinguish the scattered fibres from other elements. A list

of measurements of transverse dimensions of the fibres in the sapwood and heartwood is given below :—

	Radial Diameter in mm.			
	Heartwood.		Sapwood.	
<i>D. Ebenum</i>	...	0·013	...	0·013
<i>D. quæsitæ</i>	...	0·0076	...	0·008
<i>D. oocarpa</i>	...	0·009	...	0·010
<i>D. affinis</i>	...	0·009	...	0·008
<i>D. montana</i>	...	0·010	...	0·009
<i>D. Embryopteris</i>	...	0·009	...	0·009
<i>D. Moonii</i>	...	0·013	...	0·013
<i>D. attenuata</i>	...	0·011	...	0·012
<i>D. pruriens</i>	...	0·013	...	0·012
<i>D. acuta</i>	...	0·010	...	0·009
<i>D. hirsuta</i>	...	✓ 0·001	...	0·014
<i>D. Thwaitesii</i>	...	0·011	...	0·011
<i>D. crumenata</i>	...	0·010	...	0·010
<i>D. sylvatica</i>	...	0·012	...	0·011
<i>D. Gardneri</i>	...	0·014	...	0·012
<i>D. oppositifolia</i>	...	0·013	...	0·013
<i>D. Melanoxylon</i>	...	0·010	...	0·011
<i>D. ovalifolia</i>	...	0·0075	...	0·008
<i>D. Toposia</i>	...	0·010	...	0·010
<i>D. insignis</i>	...	0·012	...	0·011

The above table would perhaps lead one to believe that our wet country species had generally larger transverse dimensions than our dry zone species. It is also to be noticed that there is not, in every case, an increase in transverse dimensions as one passes into the sapwood, and that the maximum variation in transverse dimensions for the fibres in the whole of our species is about 0·006 mm. and for fibres of the same species less than half this amount. The transverse dimensions, thickness of wall, &c., may be greatly modified by individual forces, stress, windage, &c.

*Medullary Rays.*—These elements are, as far as the genus *Diospyros* is concerned, the most variable of all the components of the secondary xylem. Fundamentally they are similar to the wood parenchyma cells since they possess thin cellulose walls and contain abundance of starch, tannin, and oxalate of lime. Their presence in abundance tends to lower the value of the timber, their thin walls and wide lumina rendering shrinking more certain.

The medullary rays occur as radial rows of cells throughout the secondary xylem. They are, in the majority of our species, only one cell in tangential width, but in some species they may be two or even three cells wide, as in D. crumenata, D. Toposia, D. insignis, D. pruriens, D. Thwaitesii, D. attenuata, and others. The occurrence of rays more than one cell in width is never general throughout the xylem, and very frequently when the double ray is traced outwards or inwards it is found to be continuous with a ray only one cell broad. There seems every probability of discovering these broader medullary rays in the xylem of nearly all our species, providing sufficient material is examined. It is usual to find that the differentiation of a medullary ray has been going on for many years without a break, but, nevertheless, several cases have been seen where the differentiation of a medullary ray has been discontinued and where new rays have appeared ; in such cases the last or first formed cell respectively is usually surrounded with fibres only, and only occasionally with a wood parenchyma cell. As one passes into the younger wood the number of rays, not necessarily the individual cells, increases, and in the sapwood of very old trees it is not unusual to find the medullary rays separated by only one or two rows of fibres, whereas in the heartwood they are usually separated by broad bands of fibres.

This increase of parenchymatous tissue lowers the value of the sapwood timber, even though the elements may be more or less filled with the brown products so abundant in the old wood. In some specimens of D. Ebenum the continuity of a medullary ray is destroyed by the intrusion of fibres on either side of the ray ; this, however, is only local, for the same ray can be seen abutting on the inner and outer surfaces of such intrusive fibre patches.

In D. insignis, where the double rays probably reach their maximum development, the distribution is very irregular, there being from two to twenty single rays between a pair

of double rays. In tracing one ray from the younger to the older wood it was first seen to be three cells broad, and very gradually one marginal row was replaced by a row of fibres, and finally, the double ray passed into a single ray, each component having a tangential diameter equal to the sum of those forming the double ray. It has also been noticed in specimens of D. attenuata, that whenever the ray is more than one cell broad the component cells are invariably of the horizontal type, and at each end of such a ray the components are of the vertical type with large tangential diameters.

It is to be noted that whenever the ray is more than one cell broad the components have always a small tangential and large radial diameter, and many sections show a double ray superposed on a broad single ray, each ray extending vertically through a distance of many cells.

The medullary rays form large vertical strands of tissue from twelve to over thirty cells in height, the components having very variable dimensions and forming part of single, double, and triple rays.

The medullary rays, since they pass through all the secondary xylem, come into direct communication with every other type of cells, but the most striking communication is with the wood parenchyma, which they so closely resemble (particularly the vertical type) in structure, thin walls and crowded contents.

Form and size can be treated better in a combined description of the differentiation of medullary ray tissue.

In nearly every species there is a well marked differentiation into (a) horizontal cells characterized by large radial and short tangential and vertical diameters, and (b) vertical cells having short radial and large tangential and vertical diameters. In many cases one feels strongly inclined to introduce yet another type having approximately the form of a cube,

In specimens of some species, notably of D. acuta and D. Gardneri, this differentiation is only feebly exhibited.

The same ray may possess members belonging to each category, but often one type exists alone throughout a considerable length of a particular ray, and is superposed vertically on a group of the opposite type.

The vertical cells usually predominate in the very old wood, and as one passes outwards the number of horizontal cells increases until in the peripheral sapwood of very old trees they are the predominant type. Sometimes the heartwood, as in specimens of D. crumenata, shows a fairly equal proportion of horizontal and vertical cells. This increasing differentiation of the horizontal type with the age of the cambium is worthy of note.

The size of the medullary ray cells invariably increases from within outwards, and this increase, since it usually results in a radial extension of the cells, leads to an increase in the number of horizontal cells. The local occurrence of rays more than one cell in width also leads to a rapid increase in the percentage number of horizontal cells.

In the sapwood of D. insignis it appears very probable that many of the horizontal cells are parts of double rays, and the vertical cells parts of single rays, the volume of the two types being nearly the same. Nevertheless, one must realize that both types of cells may be differentiated in single rays, as in D. Ebenum and others, where double rays are very scarce or do not exist.

In the sapwood of old trees the outline of the cells is usually sharply angular; the walls are straight, and the tangential walls are frequently inclined at an angle of  $45^{\circ}$  from the vertical; in young twigs the outline is not as sharply cornered, and tends to form a crude ellipse in transverse section.

The following table of measurements will serve to indicate the differentiation in wood of various ages in all

our species. Only the average dimensions are here given:—

Dimensions of Medullary Ray Cells in mm.

[V. = vertical. H. = horizontal, medullary ray cells.]

Species.		Radial Dia- meter. mm.		Tangential Diameter. mm.		Vertical Length. mm.
D. Ebenum	... {	V. 0.015	...	0.02	...	0.06
		H. 0.06	...	0.012	...	0.035
D. quæsitæ	... {	V. 0.012	...	0.015	...	0.09
		H. 0.05	...	0.010	...	0.03
D. oocarpa	... {	V. 0.015	...	0.014	...	0.05
		H. 0.04	...	0.012	...	0.018
D. affinis	... {	V. 0.02	...	0.017	...	0.048
		H. 0.08	...	0.015	...	0.018
D. montana	... {	V. 0.024	...	0.02	...	0.034
		H. 0.07	...	0.01	...	0.022
D. Embryopteris	... {	V. 0.025	...	0.012	...	0.070
		H. 0.07	...	0.009	...	0.032
D. Moonii	... {	V. 0.02	...	0.02	...	0.08
		H. 0.036	...	0.02	...	0.03
D. attenuata	... {	V. 0.03	...	0.026	...	0.09
		H. 0.07	...	0.014	...	0.03
D. pruriens	... {	V. 0.02	...	0.018	...	0.05
		H. 0.038	...	0.010	...	0.025
D. acuta	... {	V. 0.017	...	0.02	...	0.054
		H. 0.050	...	0.015	...	0.027
D. hirsuta	... {	V. 0.022	...	0.012	...	0.12
		H. 0.04	...	0.009	...	0.06
D. Thwaitesii	... {	V. 0.024	...	0.018	...	0.078
		H. 0.08	...	0.012	...	0.023
D. crumenata	... {	V. 0.019	...	0.02	...	0.06
		H. 0.05	...	0.012	...	0.02
D. sylvatica	... {	V. 0.02	...	0.023	...	0.07
		H. 0.07	...	0.01	...	0.02
D. Gardneri	... {	V. 0.03	...	0.02	...	0.07
		H. 0.07	...	0.015	...	0.02
D. oppositifolia	... {	V. 0.019	...	0.02	...	0.07
		H. 0.055	...	0.012	...	0.015
D. Melanoxydon	... {	V. 0.02	...	0.02	...	0.056
		H. 0.05	...	0.01	...	0.027
D. ovalifolia	... {	V. 0.018	...	0.016	...	0.06
		H. 0.07	...	0.012	...	0.025
D. Toposia	... {	V. 0.02	...	0.02	...	0.09
		H. 0.05	...	0.01	...	0.035
D. insignis	... {	V. 0.03	...	0.016	...	0.08
		H. 0.056	...	0.012	...	0.018

There is, in addition to the foregoing types of parenchyma, still another which, though of rare occurrence, is worthy of description. In specimens of calamander from Karawita



forest the xylem is characterized by large radial strands, 0.09 mm. in tangential width, of very large parenchyma. These often commence at the pith and run inwards for a distance of several millimetres; they die out gradually, but frequently at the pointed end another radial patch commences and extends a considerable distance into the younger secondary xylem.

Similar strands occur in D. Gardneri from Peradeniya, the component cells being about twice the size of ordinary parenchyma and surrounded by fibres or flanked by a medullary ray. When more than one cell broad the cells are usually irregularly disposed, occasionally they exhibit a radial arrangement, though in no cases do the components exhibit the radial regularity of other elements of the secondary xylem.

The cells are parenchymatous with transverse dimensions often equal to those of the neighbouring vessels; they possess thin walls, and their contents include starch and oxalate of lime. These strands may be purely pathological, or they may perform some part in the physiology of a secondary xylem of such slow rate of growth. They cannot be regarded as parenchyma drawn from the perimedullary zone, because they appear in the sapwood of old trees; their presence in radial groups suggests an origin from the cambium similar to the broad medullary rays, and accepting this as the interpretation one must regard the final irregular disposition of the component cells as a consequence of active growth evidenced in their abnormal dimensions and numerous contents.

### **The Percentage Composition of the Secondary Xylem.**

These calculations have been arrived at by examination of transverse sections of the secondary xylem of young twigs and the sapwood of old trees. The number of elements of each type within a fixed field of view have been counted, and after several areas have been so examined for

each species the percentage composition has then been calculated.

Percentage Number of Elements in Diospyros Woods.

	Tracheal Element.	Fibres.	Wood Paren- chyma.	Medullary Rays.
<i>D. hirsuta.</i>				
Young twig, 10 mm. dia- meter ...	1.3	74.8	7.0	16.9
Old stem, 80 mm. dia- meter ...	0.60	78.8	7.1	13.5
<i>D. acuta.</i>				
Young twig, 7 mm. dia- meter ...	2.1	79.8	4.9	13.2
Old stem, 60 mm. dia- meter ...	0.4	84.4	7.6	7.6
<i>D. oppositifolia.</i>				
Twig, 11 mm. diameter	2.5	75.6	5.2	16.7
Old stem, 170 mm. dia- meter ...	0.8	79.6	6.6	13.0
<i>D. oocarpa.</i>				
Twig, 6 mm. diameter ...	1.9	74.9	10.7	12.5
Stem, 255 mm. diameter	1.0	81.8	8.9	8.3
<i>D. ovalifolia.</i>				
Twig, 7 mm. diameter...	2.3	75.5	6.3	15.9
Old stem, 240 mm. dia- meter ...	1.4	85.5	6.3	6.8
<i>D. montana.</i>				
Twig, 8 mm. diameter ...	3.0	76.9	5.9	14.2
Old stem, 175 mm. dia- meter ...	1.4	81.9	7.8	8.9
<i>D. insignis.</i>				
Young twigs ...	3.43	75.43	2.73	18.41
Average of timber, 130 mm. diameter ...	0.85	79.00	7.90	12.25
<i>D. Ebenum.</i>				
Young twigs ...	2.95	73.95	8.25	14.85
Old timber, 360 mm. dia- meter ...	0.76	85.4	6.14	7.7
<i>D. Moonii.</i>				
Young twig ...	1.70	76.11	8.45	13.74
Old timber, 170 mm. dia- meter ...	0.94	83.60	6.53	8.93
<i>D. pruriens.</i>				
Young twig, 9 mm. dia- meter ...	1.20	74.7	12.2	12.1
Old timber, 80 mm. dia- meter ...	0.84	79.64	10.24	9.28

	Tracheal Element.	Fibres.	Wood Paren- chyma.	Medullary Rays.
<i>D. attenuata.</i>				
Young twig, 6 mm. dia- meter ...	2.7	... 77.6	... 4.7	... 15.0
Old timber, 140 mm. diameter ...	0.88	... 83.84	... 3.94	... 11.34
<i>D. Thwaitesii.</i>				
Young twig, 3 mm. dia- meter ...	1.33	... 81.3	... 4.6	... 12.77
Old stem, 200 mm. ...	0.44	... 85.86	... 6.6	... 7.1
<i>D. Toposia.</i>				
Twig, 14 mm. diameter... Old stem, 250 mm. dia- meter ...	0.9 0.5	... 80.0 ... 81.2	... 7.8 ... 7.6	... 11.3 ... 10.7
<i>D. sylvatica.</i>				
Twig, 9 mm. diameter ... Old stem, 405 mm. dia- meter ...	0.8 0.55	... 81.0 ... 82.05	... 7.1 ... 7.35	... 11.1 ... 10.05
<i>D. Melanoxydon.</i>				
Twig, 10 mm. diameter... Old stem, 270 mm. dia- meter ...	2.9 1.2	... 81.2 ... 81.6	... 5.1 ... 7.1	... 10.8 ... 10.1
<i>D. Embryopteris.</i>				
Twig, 9 mm. diameter ... Old stem, 310 mm. dia- meter ...	1.2 0.6	... 83.3 ... 85.1	... 4.3 ... 7.1	... 11.2 ... 7.2
<i>D. quærita.</i>				
Twig, 15 mm. diameter... Old stem, 190 mm. dia- meter ...	1.03 0.90	... 80.0 ... 85.9	... 3.1 ... 5.7	... 15.87 ... 7.5
<i>D. Gardneri.</i>				
Twig, 14 mm. diameter... Old stem, 170 mm. dia- meter ...	0.9 0.7	... 83.0 ... 83.0	... 5.8 ... 7.5	... 10.3 ... 8.8
<i>D. crumenata.</i>				
Twig, 20 mm. diameter... Old stem, 210 mm. dia- meter ...	1.0 0.6	... 81.4 ... 83.1	... 8.8 ... 9.9	... 8.8 ... 6.4
<i>D. affinis.</i>				
Twig, 9 mm. diameter ... Old stem, 200 mm. dia- meter ...	1.5 0.3	... 84.5 ... 91.6	... 5.8 ... 3.7	... 8.2 ... 4.4

This table is instructive as affording data to show the change which takes place in point of percentage number, as one passes from the oldest to the youngest xylem, and also

to give a systematic value to the percentage composition of the xylem.

*Change in Percentage Number of Elements in Old and Young Xylem.*—In every species the percentage number of tracheal elements decreases with the age of the cambium, the first formed xylem having the maximum percentage number and the last formed the minimum. The number of tracheal elements in the heartwood may reach 3.43 per cent. as in D. insignis, or be as low as 0.8 per cent. as in some specimens of D. sylvatica; this is a very low number, but in the sapwood it is still lower, the maximum being 1.4 per cent. in D. ovalifolia and D. montana and the minimum 0.3 per cent. in D. affinis.

Hence we see that the percentage number of tracheal elements in young and old xylem of all our Ceylon species does not vary more than 3 per cent., and the relatively low percentage number will serve to systematically diagnose the secondary xylem of our species of Diospyros. The tracheal elements are represented by a lower percentage number than any element of the parenchyma type, and this is to be correlated, perhaps, with the evergreen nature and very slow rate of growth of all the Ceylon species.

The thickest leaved species have a very low percentage of tracheal elements in the sapwood of the mature tree, as for instance D. acuta with 0.4 per cent. and D. affinis with 0.3 per cent. The thinnest leaved species in the dry zone is D. montana, with a percentage number of 1.4 in the sapwood, whereas the thinnest leaved species in the wet zone, where the temperature is never very high and the air is always moist, is D. attenuata with a percentage number of 0.88 in the sapwood of stems 140 mm. diameter.

Though knowledge of the individual variations prevents one from attaching too much importance to similar features in different species, yet it is worthy of note that in every species growing in the wet zone the percentage number of tracheal elements is approaching the minimum, as in D.

Gardneri, 0·7 per cent., D. hirsuta 0·63 per cent., and D. Thwaitesii 0·44 per cent. ; whereas in the majority of our dry zone species the percentage number is considerably increased, e.g., D. montana 1·4 per cent., D. ovalifolia 1·4 per cent., D. Melanoxyton 1·2 per cent.

The facts of histological differentiation are therefore in general accord with the varying climates and the transpiration which probably occurs under these conditions.

As previously shown, the decrease in percentage number from within outwards is concomitant with a regular increase in transverse dimensions.

The parenchymatous elements compose the remaining part of the secondary xylem, and are mainly represented by fibres. The fibres constitute from 74 to over 90 per cent. of the total secondary xylem elements.

The wood parenchyma, together with the medullary ray cells, tend to form an approximately constant proportion in the xylem of different ages within the same tree. Generally speaking, the percentage number of medullary ray cells decreases from within outwards, this decrease being concomitant, as in the case of the tracheal elements, with an increase in size ; whereas the percentage number of wood parenchyma cells, though generally increasing from within outwards, is apt to show a steady percentage number, or even a decrease from within outwards. The approximation to a constant proportion in the old and young wood is seen in D. insignis (20·15 and 21·14), and, as pointed out in a previous paragraph, it is often very difficult, owing to feeble lignification of surrounding fibres, to be absolutely certain, in transverse sections, whether one is dealing with fibres or wood parenchyma. 1.27

Though the percentage number of wood parenchyma cells, in the majority of our species, increases in the younger wood, the difference in percentage number is rarely over 3 per cent. of the total number of xylem elements. In the xylem of D. ovalifolia, the percentage number in the wood of a young twig and the sapwood of a tree 240 mm. diameter proved

to be the same, viz., 6.3 per cent., and in other cases a reduction in percentage number has occurred in the sapwood. It is therefore obvious that the percentage number of wood parenchyma cells is the most unstable of the secondary xylem elements, since all other elements show a definite increase or decrease.

The fibres in virtue of their abundance and constitution are the most important from an economic point of view. The most parenchymatous woods, such as those of D. insignis, rarely contain less than 79 per cent. of fibres, and, on the other hand, the xylem of several species contain over 90 per cent. fibres.

From the table quoted it will be seen that the percentage number of fibres gradually increases from the heartwood to the sapwood, and in this respect is almost alone among the secondary xylem elements. The gradual increase in percentage number in passing into the younger wood is concomitant with a decrease in the percentage number of tracheal elements and medullary ray cells. The increased weight of foliage, &c., consequent on age and development is perhaps sufficient reason for the production of an increased percentage number of fibrous elements.

The percentage number of medullary ray cells comes next to those of the fibres, and varies from 6 to over 18 per cent. of the total number of xylem elements.

The highly parenchymatous woods are characterized by a particular abundance of these elements, and in all such cases the quality of the timber is inferior, as in D. insignis, D. hirsuta, and D. oppositifolia.

As with the tracheal elements, a decided reduction in percentage number occurs as one passes from the heartwood to the sapwood, but this is accompanied by an increase in dimensions, especially in the radial direction. In the sapwood of most species the enormous size of these elements is apt to create an erroneous idea of their percentage number; the decrease in the latter is fully compensated by the increased dimensions.

### Rings of Growth.

These are inconspicuous in the majority of our species. According to Ursprung the timber of some species of *Diospyros* presents well defined rings of growth when the trees have been grown under a subtemperate climate.

The whole of our Ceylon species are characterized by a slow rate of cambial activity, and, with the exception of the partially deciduous trees of *D. montana* and *D. ovalifolia*, may be regarded as typical evergreens. Nevertheless, the majority of our species are characterized by foliar periodicities which recur, fairly regularly, year by year, and these together with the independent effects of a hot dry season, are perhaps responsible for the zoned differentiation often met with. We have also to allow for the possibility of special periods of activity determined by internal forces and expressed in the differentiation of irregular patches of xylem. In the majority of the specimens examined the inconspicuous rings have been difficult to follow throughout the whole of any transverse section, many being tangential bands in association with a neighbouring branch, and therefore roughly limited to the side on which the branch occurred. In timber of *D. insignis* and *D. Thwaitesii* rings of growth are visible to the naked eye, and consist of broad dark bands alternating with narrower bands of a lighter colour. The narrow light rings vary from 0.2 mm. to 1.2 mm. in radial diameter, and are disposed at very varying distances—radially—from each other.

The rings of growth are often present in one part of the section and gradually merge into adjacent rings of growth, and in consequence of this, and the varying radial distances (2 to 8 mm.) between successive rings, we find that the number of rings along different radii is subject to great variation. It is impossible to at present determine in our Ceylon ebonies the exact representation of time of each ring of growth.

### Rate of Growth.

The genus *Diospyros*, in Ceylon, possesses some of the most slowly-growing tropical trees. In the seedling and sapling stages, up to the first ten or twelve months the growth takes place at a fairly rapid rate; seedlings two months old may measure, above ground, from 30 to 150 mm. according to the length of the hypocotyl, but in two and a half years the total height may exceed 3,300 mm.; saplings ten years old may measure less than this, and the subsequent growth takes place at a slow rate. The following are the dimensions of two and a half years old saplings raised in the same plot at Peradeniya:—

Species.		Height. mm.		Circumference. mm.
<i>D. montana</i>	...	3,610 (11 ft. 10 in.)	...	111
<i>D. Ebenum</i>	...	1,828 (6 ft.)	...	84
<i>D. Embryopteris</i>	...	1,220 (4 ft.)	...	81
<i>D. quæsita</i>	...	610 (2 ft.)	...	38

Some species never develop into large trees, *e.g.*, *D. acuta* and *D. pruriens*, but the majority of Ceylon species attain huge dimensions, particularly *D. sylvatica*, *D. crumenata*, and *D. affinis*. There are, however, very few trees of known age, and exact information cannot therefore be obtained. There is one specimen of *D. quæsita* in the gardens, which, though known to be over sixty years old, measures only 472 mm. in circumference and a total height of about 14 metres; this, however, is one of our slowest growing species; other species, notably *D. Embryopteris* and *D. montana*, probably grow at a much quicker rate.

Sample plots for observing the rate of growth have been established by the Ceylon Forest Department, and yearly observations have been made on selected trees in the various forests; the results are, however, at great variance.

Broun states that after reaching a circumference of 914 mm. (3 feet) *D. Ebenum* is very slow growing, and that the tree may reach a circumference of 457 mm. (1 foot 6 inches) at the age of 25 years, 914 mm. (3 feet) at 75 years, 1,372 mm. (4



feet 6 inches) at 135 years, and 1,828 mm. (6 feet) at the age of 200 years.

The following observations were made on trees growing in the Peradeniya Garden :—

Circumference of Trees in Millimetres.

Date of Observation.	Species.			
	D. Embryopteris. mm.	D. Gardneri. mm.	D. Ebenum. mm.	D. quæsita. mm.
August 13, 1900...	585	... 467	... 147	... 370
January 1, 1901 ...	587	... 468	... 147	... 382
July 2, 1901 ...	600	... 468	... 156	... 400
August 6, 1902 ...	630	... 474	... 162	... 430
August 12, 1903...	673	... 496	... 179	... 472
Increase in cir- cumference in three years ...	88	29	32	102

The selected trees were of unknown age, and, as is shown in the first measurements, of widely different dimensions ; it is, nevertheless, of interest to know that in trees of the selected species the increase in circumference may be from 29 to 102 mm. in three years' time. This increase may be due to phellogenetic activity as much as that of the vascular cambium, but assuming that the increase in circumference is due to the production of secondary xylem only, we find that that in D. Ebenum is equal only to 62 vessels, or an average of one to two vessels along each radius, per month during the three years in question.

### Timber.

The genus Diospyros has obtained its widespread recognition mainly in virtue of the valuable timber yielded by several of its species. The term *ebony* is loosely applied to any black heavy wood capable of taking a good polish, and from time to time there has been considerable discussion as to the exact botanical source of the ebony of the ancients. Many plants are known to yield timber which in colour and density resembles the real ebony, and botanists have been found who assert that the ebony of the ancients was not

obtained from the genus *Diospyros*, but from a leguminous species, called Fornasinia ebenifera, Bertol. The natural order Leguminosæ has long been known to yield variously coloured timbers, and in some countries the respective species furnish a marketable ebony, *e.g.*, Dalbergia Melanoxylon, G. and P., the ebony of tropical Africa, and Brya Ebenus, DC., the Jamaica ebony.

In Ceylon, however, the ebony of export is obtained exclusively from species of *Diospyros*, and mainly from the trunks of D. Ebenum. This ebony has been known from distant times, and some botanists believe that the ebony mentioned in the Bible was obtained from this Island.

According to Trimen\* the tree was not known to Hermann, and only the timber of it to Burmann,† who quotes from Grimm‡ as to its medicinal virtues.

Rumph§ states that ebony trees are abundant about "Trinkenemale," and Trimen believed this to be the earliest record of our most important ebony-yielding trees in Ceylon.

The ebony is obtained by felling the tree and stripping off the peripheral sapwood. It is usual to fell all those trees which have attained or exceeded a breast-height circumference of 2 metres ( $6\frac{1}{2}$  feet), providing the preliminary examination indicates the existence of a good proportion of solid black heartwood. The preliminary examination usually consists of making an incision and determining the extent to which the discolouration has proceeded; in some cases an apparatus known as Pressler's increment borer is used, as by this means only the minimum damage is done to the timber, and the tube can be easily withdrawn and the cylinder of wood extracted from the stem. In Ceylon the felling of the ebony trees is carried out on definite principles, each officer clearing only those trees which have

\* Trimen, *Flora*, Vol. III., p. 95.

† J. Burmann, *Thesaurus Zeylanicus*, 1647.

‡ Grimm, *Laboratorium Ceylanicum*, 1679.

§ G. E. Rumphius, *Herbarium Amboinense*, 1750.

attained the standard dimensions, and at such a rate that only one-fortieth to one-sixtieth of the forest acreage under his charge is cleared each year.

The occurrence of ebony within the plant cannot be stated in terms of the age of the tree, the dimensions of the stem, or the climatic conditions under which the plants have been grown, though a few facts capable of a very general application may be here given. The black heartwood occurs usually in the stem, but is often present in young twigs and roots. In the majority of our species the discolouration commences in the perimedullary zone and spreads from within outwards. The discolouration is usually of an uniform black in D. Ebenum, streaked in D. oocarpa, D. affinis, D. quæsitæ and others, red in D. Moonii, and a dirty white in such species as D. insignis and D. attenuata. The discolouration may occur in the oldest central wood only, or it may appear in local strands throughout the secondary xylem of the stem. In many young stems the only areas where ebony has been produced are directly associated with insect punctures, wounds, &c.

The occurrence of the central black wood within the length of the stem is often erratic, though most usually it decreases in volume from below upwards.

The eccentric formation is where the central column of black wood widens and narrows repeatedly at different points along the stem, and in consequence of this one cannot accurately estimate the volume of ebony in a stem by external observations alone. In some instances, particularly in young stems and twigs, the black heartwood repeatedly dies away and reappears at different points along a given length.

The age of a particular tree or the dimensions it has attained do not afford a sure criterion as to the quantity of ebony it will possess, though the probabilities are that the older the tree and the larger the dimensions, the greater will be the proportion of discoloured heartwood. This

uncertainty has long been recognized by persons engaged in financial speculations, and too much stress cannot be laid on the individual variation which occurs in trees of the same species from the same or different localities.

On the other hand, there can be no question as to the specific tendencies to produce a definite type of heartwood, though even here one has to allow a wide range of variability for each species. For instance, the heartwood of D. Melanoxylon and D. Ebenum is almost invariably jet black, and on this account these two species provide the greater part of ebony from India and Ceylon; D. insignis, on the other hand, never yields a black heartwood, D. Gardneri always produces a yellow wood, and D. Moonii a timber which is of a red tint spotted here and there with small black strands. There could be no possible doubt of the species were the timbers of D. Ebenum, D. Kurzii, D. insignis, and D. quæsitæ to be mixed with one another, as their macroscopic characters are so pronounced.

The specific colour tendencies are somewhat difficult to explain. The two factors which determine the colour of the timber in the respective species are : (1) the means of distribution of the coloured substances ; (2) the proportion of coloured gum and resin present in the tissues.

It is perhaps safe to assume that the best or most general distribution of coloured substances will be effected in those xylems the elements of which are freely communicating with one another, and therefore those species the timbers of which contain a high percentage of medullary ray cells and wood parenchyma should show the most general distribution of colouring substances. The fact that the xylem of D. insignis is highly parenchymatous and is really white points to the conclusion that for the production of ebony the superabundance of colouring material is the first desideratum, rather than profusely pitted elements. An open type of pit communication between the elements will tend to prevent the formation of central ebony in timbers where the colouring

substances are not abundant. The central timber will tend to become dark in colour when the communication between the elements is not frequent, as the substances must then remain in approximately the same area in which they were formed.

The jet black colour of the timber of species such as D. Ebum is due to the coloured substances being present in large quantities in the oldest wood and remaining approximately in that area. If a more open communication existed between the elements in this species the colouring materials would be more widely distributed and the central timber deteriorate in consequence.

The red, yellow, or white colour of many *Diospyros* timbers is due either to the more complete distribution of the colouring substances throughout the wood in the respective species or to the relative scarcity of coloured substances.

The climate does not appear to have any appreciable influence on the production of discoloured heartwood, the same species showing similar characters in the dry, wet, and intermediate zones of Ceylon. The majority of our ebony is obtained from the dry zones in the northern part of Ceylon, because D. Ebum grows more luxuriantly there than elsewhere, and not because the black timber of this species is more abundant, per tree, or of better quality than that from the scattered trees of the wet zone.

It is, however, generally believed by Ceylon foresters that the nature of the soil exerts some influence on the proportion of discoloured wood. Many cases have occurred where the trees growing on rocky hill banks possessed large quantities of black heartwood, and the proportion of ebony decreased as one got on to better soil. According to Broun the best ebony in Ceylon is found on rocky well-drained soil. It grows well on soils containing a large quantity of clay and on sandy loam with a good subsoil drainage.

The general belief is that the proportion of discoloured heartwood tends to increase in trees grown on poor rocky soil. This is substantiated by every forester I have met.

The durability of our *Diospyros* timbers is due to the nature and percentage number of the elements comprising the wood, together with the presence of coloured contents partially or wholly filling the elements. In all our Ceylon species of *Diospyros* the cambium divides very slowly, and the elements, particularly the fibres, possess small transverse dimensions and thick walls ; the percentage number of fibres is in every case very high, and that of the tracheal elements very low, consequently the xylem is much more durable than the majority of our Ceylon timbers. Nevertheless, the histological composition of the secondary xylem is only one factor in determining the durability of these timbers, the infiltrated gums and resin providing a substantial support to the otherwise empty elements. The relative durability of the outer white sapwood and the central ebony is well seen in trunks of trees exposed to the atmosphere and vermin ; the sapwood is stripped completely in a few years, leaving a smooth black log of ebony which resists the attacks of ants and many wood borers.

### **Discolouration of Timber.**

The discolouration of the wood is mainly due to chemical and physical changes of the materials stored in the elements of the wood, and to a less extent to a change in composition and colour of the cell walls. The coloured material entirely fills the lumina of the elements in pure ebony, and decreases in quantity as one passes to the red, yellow, and white woods. The white sapwood surrounding the central ebony contains a varying quantity of coloured material partially filling the secondary elements, and the quantity of this material increases from without inwards.

To the naked eye there appears to be a sharp distinction between the limit of the central ebony and the white sapwood. A gradual series of changes can, however, be discerned in microscopic sections, and for the conversion of the peripheral sapwood into ebony it is mainly a question of time.

Usually the ebony or heartwood occurs as a fairly regular circular mass at any particular level in the stem ; when the ebony is not limited to xylem of the same age the projections towards the sapwood are associated with wounds or old branches.

To explain why the limiting line of the central ebony is so sharply defined, or, in other words, to explain why the coloured substances occur so definitely in xylem of the same age, we must consider the distribution and pit communication between the different elements. In the first place we must admit that the wood parenchyma, medullary ray cells, and tracheal elements are abundantly supplied with large pits on all surfaces, whereas fibres are but sparsely pitted.

The tangential bands of wood parenchyma serve as excellent means for the transference of coloured substances through xylem of the same age, from like cells or those of the medullary ray to the tracheal elements or the short parenchyma surrounding them.

The frequency of the pits between the wood parenchyma, medullary ray cells, and tracheal elements is one reason why the circulation of the coloured substances, originating in the parenchymatous elements, should tend to keep within these elements. The fewness of pits in the fibres does, on the other hand, account for their sparse contents and the fact that they are the last elements to have their lumina filled with the coloured substances.

We therefore see that the maximum facility is accorded for transference of the coloured substances tangentially through the wood parenchyma and tracheal elements rather than radially through the wide patches of sparsely pitted fibres, and this will perhaps serve to explain why the coloured substances tend to first fill the elements in xylem of approximately the same age and thus lead to the sharp line of distinction between the outer limit of the ebony and the white sapwood.

At the same time the transference of coloured materials can and does take place in the radial direction, from one

medullary ray cell to another, but the proportion of these elements is so small compared with the surrounding fibres, that any contents they may possess cannot greatly change the tint of the xylem as a whole.

When the parenchymatous and tracheal elements have their lumina blocked the coloured material gradually infiltrates into the fibres. The coloured substances, under normal circumstances, first appear in the oldest elements, and therefore the blackening takes place from within outwards.

The composition and origin of the discolouring substances has been discussed by Belohonbek, Hartig, Molisch, and Moeller. They all regard the coloured materials as being singular in chemical constitution, and the terms "gum" and "resin" have been frequently applied to the separated substances.

The coloured substance is partially soluble in water, creosote, benzene, ether, and sulphuric acid. The solution varies in colour from a deep brown to claret red. In all cases microscopic examination of the sections so treated shows that only a very small proportion of the coloured substance has been extracted. If the sections are treated with strong sulphuric acid for several days the walls of the elements disappear and liberate long black rods of material which resist the attack of the strong acid even after heating. These black carbon-like rods appear to be unaffected after treatment with any reagent. Mr. Kelway Bamber has very kindly made an analysis of the coloured timber, and has allowed me to quote his results here :

<i>Ebony Dust.</i>					Per cent.
		Per cent.			
Moisture	...	14.36	Water extract (soluble	...	
Organic matter...		77.84	gum)	...	3.60
Ash	...	7.80	5 per cent. NaOH ex-	...	
			tract	...	7.24
		100.00	Residue (dark rods)	...	67.00
			Ash in residue	...	7.02

Mr. Bamber finds that the 5 per cent. caustic soda solution contains a gum precipitable by alcohol, and a resinous body,



dark reddish brown in colour, which can be extracted from the original ebony dust with alcohol and amounts to 3·58 per cent. of the dust.

The black colouring material therefore contains two gums, one resin, and an insoluble residue composed mainly of carbon.

It has been asserted that the colouring materials arise by chemical change of the inner layer of the elements in which they occur, and even Molisch believed that the reputed thinness of the walls of some vessels was due to part of the material having been so modified. My own observations do not confirm this theory, though I have noticed a certain amount of swelling when sections of the fresh wood are placed in water. This is probably due to the absorption of water by the thin layer of gum which forms a lining to the tracheal elements, and which occurs in the yellow or white sapwood of ebony-bearing species.

From an examination of longitudinal sections of the sapwood and heartwood of our species I have concluded that the greater part, if not the whole, of the coloured materials filling the lumina of the elements is derived from the materials accumulated in the parenchymatous system of the secondary wood. Usually the discolouring substances make their first appearance in the cells of the medullary ray or wood parenchyma, then in the tracheal elements, and lastly in the fibres.

The parenchymatous elements of the sapwood are invariably packed with starch grains, tannin, and calcium oxalate. The starch grains gradually lose their regular outline and a fine granular texture becomes obvious, together with a change in colour. Finally, globules suggestive of a resin or gum appear in the parenchyma cells, and as these increase a deepening of tint from yellow to brown occurs. It would therefore appear that by a series of chemical changes the contents of these elements gradually disintegrate, and the resulting compounds are in the form of globules of coloured material. It must, however, be remembered that starch is a stable

substance, and also that the disappearance of many grains is due to their conversion into sugar for uses within the plant, and may not be associated with the coloured globules under consideration. If one examines the vessels of the sapwood one often finds the globular material entering through the pits. In one section the stream of coloured material could be traced from the medullary ray cells through the pits into the lumen of the wide vessel with which they were in contact.

In very many cases the coloured substances project into the lumen of the vessel as large globules suggesting tyloses; these swell, and are partially soluble in water. The globules may exhibit stratification according to the colour of the different parts.

In other cases the large globules are entirely absent, and the deposit appears as a thin film of a pale straw-coloured material in the area of the pits. The whole of the pits in the wall of any particular vessel do not usually present this appearance, the pits thus coloured usually occurring only in local groups along the wall of the vessel. The deposit may become very abundant, and when half filling the vessel is irregularly globular in outline. It therefore appears that the material occurring in the tracheal elements is derived from the substances stored in the parenchymatous elements, and the relative freedom of the latter from contents—a feature often noticeable in mature ebony—may be a consequence of exhaustion of store material. The infiltrating material may be of a pale straw or light brown colour; as it increases in quantity the tint deepens and the elements finally become blocked with deep brown or black material.

The gum-resin issues in large quantities from the stumps of freshly felled trees and accumulates at points of exposure. The walls of the elements from trees which have yielded large quantities of this substance do not show any reduction in thickness, and it is probable that they have been derived from disintegration of store materials in the parenchyma of the wood.

The stratification exhibited by the deposit is due to the variation in the colour of the different parts, and may be detected in the globules formed within the parenchymatous elements.

The maximum quantity of gum-resin is seen in our blackest woods, such as D. Melanoxylon and D. Ebum, and the minimum in our whitest woods, such as D. insignis and D. hirsuta.

The mottled colour of some timber specimens is due to the gum-resin being almost limited to the medullary ray cells; these are packed with the brown-coloured substances, while the neighbouring elements, including vessels, are nearly empty. This feature is noticeable in our lighter coloured woods, such as D. Gardneri, D. sylvatica, and D. insignis.

The appearance of the material in the vessels may occur unaccompanied by any change in the physical properties of the wall, and the fuchsin and safranin reagents can still be used with advantage, even when the elements are entirely filled with the coloured substances. In many cases the coloured substances impregnate the walls of the elements, but only in few cases do the walls show signs of decay.

#### V.—SEEDLINGS. *M. 55-67.*

In the development and anatomy of the seedlings several interesting points have been determined, and a synopsis is here given. The characters of seedlings have not yet found a prominent place, if one at all, in systematic monographs. The occurrence of specific and generic characters in the developmental phases, in the morphology of the cotyledons and epicotyledonary leaves, and in the behaviour of the leaf traces must serve as the reasons for their inclusion in the present work.

The importance of seedling characters for systematic purposes has of late been discussed by various botanists.

Miss Sargent\* has stated that no doubt remains as to the systematic value of the indications given by the vascular

\* Ethel Sargent, The Origin of the Seed-leaf in Monocotyledons; New Phytologist, Vol. I., No. 5, 1902.

structure of the cotyledon, hypocotyl, and primary root. At a later date\* a further contribution was made on the same subject, and in it a very great significance was alleged for seedling characters. Though the examination was mainly with seedlings of the Liliaceæ and Ranunculaceæ, the evidence seemed sufficient to justify the publication of a theory of the origin of monocotyledons founded primarily on the structure of their seedlings. This theory was again discussed at the British Association meeting, September, 1903. Fritsch,† in a general discussion on the value of anatomical characters, states that though seedlings may present a very uniform type of structure throughout large groups, the anatomy of the seedling may be expected to indicate affinities more clearly than that of any other part of the plant.

The length of the hypocotyl and primary epicotyledonary axis, the phyllotaxy, and general morphology of the first formed leaves, together with the persistence or dropping of the cotyledons, provide ample material for the recognition of most Ceylon species of *Diospyros*. In addition to these characters we have to consider the number of traces per cotyledon, and the behaviour of the epicotyledonary and cotyledonary traces in the hypocotyl and primary root; these in themselves afford facts sufficient to allow one to construct a useful artificial key for the identification of Ceylon species.

*Germination.*—The time taken for germination varies according to the condition of the seeds when gathered and sown. If sown after partial drying in air, germination usually occurs within two to four weeks. If, however, the fresh seeds are sown direct, without drying, it may take several months before the primary root projects from the micropyle. The seeds of *D. ovalifolia* have a particularly

\* Ethel Sargent, A Theory of the Origin of Monocotyledons founded on the Structure of their Seedlings; *Ann. Bot.*, Vol. XVII., No. LXV., January, 1903.

† F. E. Fritsch, The use of Anatomical Characters for Systematic Purposes; *New Phytologist*, Vol. II., No. 8, October, 1903.

hard testa and a copious horny endosperm, and many do not germinate until nine months after sowing.

The material required for the study of the vascular system prior to the production of secondary elements is best obtained by allowing the seeds to germinate on sheets of blotting paper, which are always kept moist, or on porcelain dishes partially immersed in water and covered by a bell jar.

If it is desirable to study the embryo prior to the appearance of lignification of the proto-elements, a convenient method is to first thoroughly dry the seeds until the testa begins to crack and then immerse them in water kept at 100° F. for some time. Seeds of D. Ebenum treated in this way provided excellent material, since the embryos completely emerged from the confines of the endosperm into the bath without being injured in any way.

### **Development of the Seedling.**

When the primary root has attained a length of 2 or 3 cm. the young curved hypocotyl appears above ground. The cotyledons are embedded within the copious endosperm, and together with the testa are still below the surface of the ground. Subsequently the hypocotyl shows signs of rapid growth, the collet area increases in thickness, and the hypocotyl becomes more strongly arched and sooner or later assumes an erect position, carrying at its apex the cotyledons or epicotyledonary leaves. In every Ceylon species of Diospyros and also Maba, the seedlings are of the epigeal type, though the mode of development in those species having very short hypocotyls is suggestive of a hypogeal habit.

In a few of our species, viz., D. Ebenum, D. Gardneri, D. sylvatica, and D. montana, the pair of opposite ovate cotyledons persist for many months and function as assimilatory structures until an adequate system of epicotyledonary leaves has been established. In all such cases the epicotyledonary leaves develop very slowly. This is true for seedlings

raised from seed obtained from cultivated trees in India and Ceylon and from the jungle. The delayed epicotyledonary development is characteristic only of those species which have normal persistent cotyledons. It is also to be noticed that in all these cases the primary epicotyledonary axis, *i.e.*, axis between cotyledonary node and first epicotyl leaf, is very short, and that the first two leaves on this axis never form an opposite pair, but are always arranged alternately, and are speedily followed by many others disposed in a similar way. .

The majority of our Ceylon *Diospyros* species exhibit a curious mode of development, and a detailed account of seedlings of *D. quæsita* is now given, commencing at the stage of the strongly arched hypocotyl, when the testa, endosperm, and cotyledons are still connected with the hypocotyl and partially covered with soil. At this stage the testa splits near the micropyle, and the gap thus formed gradually extends along each side of the seed to a distance of about 1 cm. The chalazal end and often the greater part of the seed is still below the surface of the soil. In consequence of the strain set up by the rapidly growing hypocotyl the sessile cotyledons now become detached and the hypocotyl frees itself from the confines of the seed, carrying the enhanced epicotyledonary leaves at its apex. The cotyledons are left behind surrounded by the bulky endosperm, and from the moment of their detachment the young seedling receives no further nutritive substances from the endosperm. At this stage there is a large quantity of endosperm, and this, together with the whole of the reserve materials contained in the parenchyma of the cotyledons, is wasted. In consequence of the detachment of the cotyledons and the enhanced development of the epicotyledonary leaves a large number of the seedlings die. This is brought about by the death and decomposition of the cells of the detached cotyledons and the endosperm, which in time leads to a diseased condition of the apex of the epicotyledonary axis. It is therefore highly desirable to apply artificial pressure and crack the

testa sufficiently to allow the cotyledons to escape prior to detachment.

The cotyledons, though they have attained their full dimensions and are exposed to light, never take on the work of assimilation as in the case of the species with normal persistent cotyledons. They are at first pale yellow in colour, but within twenty-four hours show signs of death, and within thirty-six hours become black and shrivelled. They may, however, still adhere to the cotyledonary node by the bases of their short petioles.

The point of interest in this curious suicidal mode of development is that the disconnection of the cotyledons seems to have been provided for long before the actual detachment takes place. Ungerminated embryos show a conspicuous epicotyledonary axis usually with a minute pair of interlocked leaves at the apex. In those species with persistent cotyledons such an enhanced epicotyledonary development does not present itself until three or even five months subsequent to the full exposure of the cotyledons. By the time the cotyledons are detached the epicotyledonary leaves are well developed ; they are also provided with a palisade tissue, and on exposure take on the work of assimilation usually allotted to the cotyledons. Furthermore, the first epicotyl leaves usually form an opposite pair of interlocked leaves, and thus remind one still more forcibly of cotyledons. When the epicotyl leaves form an opposite pair these usually persist alone for many months ; this suggests most strikingly that their enhanced development has really been an effort, and internal evidence indicates that it is associated with abortion of cotyledons, which appears to have been taking place through many generations.

The majority of our species show this detachment of cotyledons and enhanced development of epicotyledonary leaves which take on the work usually assigned to cotyledons. The cotyledons never acquire palisade tissue, but this layer

is laid down in the epicotyledonary leaves long before they are exposed to light.

As to the causes which lead to the detachment of the cotyledons, it is very difficult to make any definite statements. The regularity of the occurrence in seeds of all sizes, under natural and artificial conditions, is suggestive of the possibility of a definite cellular activity cutting off the cotyledons at the node in a manner similar to that in which old leaves are cut off from the parent tree. This, however, cannot be the case, as in all experiments where the cotyledons have been set free prior to detachment their dead and shrivelled tissues have persisted at the cotyledonary node for a considerable length of time.

Hence we are driven to the conclusion that the detachment is probably a case of separation under conditions of strain, and several possible factors may be quoted in support of this contention. The first is the pressure of the endosperm. In those species where the cotyledons are persistent the endosperm may be equable (*D. Ebenum*) or strongly ruminant (*D. sylvatica*); similarly it may be markedly ruminant in species with detached cotyledons (*D. hirsuta*) or equable (*D. insignis*). Hence, the pressure of the endosperm, as indicated by the absence or presence of ruminations of this substance, has probably very little to do with the detachment of the cotyledons. A second factor is probably to be obtained in the bulk of the endosperm, testa, &c.; for though *D. ovalifolia* may prove exceptional, it is a fact that those species with persistent cotyledons have relatively a smaller quantity of endosperm which is necessarily exhausted early, resulting in a shrinking of the testa and liberation of the cotyledons at an early date.

However, neither of the foregoing, even if coupled with the increased resistance of the irregular surface of the mature cotyledons, can completely explain the cause of detachment.

The chief cause, in my opinion, is to be found in the insufficient splitting of the testa; in *D. pruriens* and *D.*



ovalifolia there is no splitting of the testa, and it is impossible for an expanded cotyledon to effect its exit from such a small circular micropylar opening amply filled by the thin axis of the hypocotyl; in other species there is only a partial splitting, and even in calamander seeds the gap is never large enough to allow the cotyledons to escape intact.

Since the splitting of the testa would be more complete if the endosperm were exhausted more quickly, it follows that probably all the forces mentioned above play some part in the final detachment of the cotyledons.

The mode of development just described is not a consequence of the artificial raising of the seeds; the detachment occurs in nature, and the internal characters of the epicotyledonary and cotyledonary traces indicate that this line of development has been habitual for a considerable period of time. This mode of development is characteristic of some of our rarest species, and is probably one of the factors which is leading to the extinction of many species.

The detachment of the cotyledons is attended with the minimum disadvantages in those species having short hypocotyls (D. insignis and D. Embryopteris). In these instances the seed coat, endosperm, and cotyledons are but rarely raised above the surface of the soil, and the young though enhanced epicotyledonary parts gain easy exit.

The habit of D. insignis in particular is very suggestive of a hypogeal tendency, since the seeds are rarely raised above ground, the hypocotyl is very short, and the epicotyl stem very long and provided with small leaf rudiments suggestive of typical Garcinia seedlings.

The morphological relationships of the parts of the seedlings are also of interest. In the first case it is worthy of note that in those species possessing short hypocotyls the epicotyledonary axis is usually long (4 to 7 cm.), whereas in those having hypocotyls of normal length the epicotyledonary axis is usually only from 0.5 to 1.5 cm. in length.

By this coincidence the first series of pronounced epicotyledonary leaves are brought to approximately the same height above ground in all species.

The lengths of these axes are fairly constant in each species, the median length of hypocotyls being from 5 to 7 cm. as in D. Ebenum and D. Thwaitesii; short hypocotyls, about 1 to 2 cm. as in D. insignis; and long hypocotyls, being from 10 to 11 cm., as in D. crumenata and D. quæsitæ.

The cotyledons are in all cases of the broad ovate type with blunt or tapering apices and attached by very short petioles at the cotyledonary node.

The first epicotyledonary leaves are, in the majority of our species, opposite; in one species they may be opposite or sub-opposite, and in the remaining species they are alternately disposed on an elongated axis. In all cases the leaves are simple, ovate-lanceolate in shape, but show differences in size and venation in the respective species. Generally speaking, they possess the diagnostic feature of the leaves of the mature plant in all points except size.

### Internal Characters of the Seedlings.

In every species the number of traces per cotyledon is constant, and we have to separate those possessing two traces per cotyledon (*e.g.*, D. Ebenum and D. Gardneri), from those with three (*e.g.*, D. crumenata and D. Embryopteris).

In those possessing two traces per cotyledon the cotyledons are usually persistent; the cotyledonary traces are prolonged into the primary root and the epicotyledonary traces die away immediately below the cotyledonary node.

In those species with three traces per cotyledon the majority are characterized by detachment of cotyledons and enhanced epicotyledonary development, and though there are three traces per cotyledon the xylem and phloem of the median trace are abortive in all species except D. pruriens.

Furthermore, in those species with deciduous cotyledons the epicotyledonary traces are continued through the hypocotyl into the primary root.

The tendency for the median cotyledonary trace to abort is what one may expect in those species where the cotyledons are defunct at such an early period, and the prolongation of the epicotyl traces into the root is rendered necessary since nutritive substances cannot be absorbed from the endosperm. The fact that the embryo shows these structures fully differentiated points to a past history in connection with these curious developments.

The traces of the cotyledons are provided for the conduction of food materials absorbed from the endosperm to all parts of the seedling; in those species with persistent cotyledons they are the only vascular tissues present during the first few weeks or months of the seedling's life. If the absorbing tissues and the reserve food are cut off from the seedling during this phase, the young plant must die if the epicotyledonary traces are not prolonged into the root to establish a connection between the growing point of the stem and the new absorbing tissues constituted by the primary root.

It is very doubtful whether such developments can be accomplished in one generation, and the definiteness of the median trace abortion and epicotyledonary prolongation are sufficient evidence that the curious mode of development has been going on for many generations past.

There are, however, several facts which point to a very unstable condition. Seedlings of the same species show considerable variation in the degree of differentiation of the different tissues, and also in the behaviour of the vascular strands in the region of the collet. In one seedling the epicotyledonary and median cotyledonary traces were absent from the primary root at a distance of 2 cm. from the apex; at this point only the four lateral cotyledonary traces were present, though in the hypocotyl the six cotyledonary and two epicotyledonary bundles were in evidence; in this case the median cotyledonary trace had apparently suffered complete abortion at a point which had not yet been reached

by the descending epicotyledonary trace, and thus indicated one of the possible stages in the establishment of a new root symmetry.

*Splitting of Xylem Traces.*—Another point which indicates most markedly the unstable conditions of the seedlings is seen in the splitting of the xylem of the leaf traces. This is best seen in seedlings which are very young and in which vascular cambium has not made its appearance, and for the sake of clearness a description of the behaviour in D. Embryopteris is here given. At the cotyledonary node three vascular bundles make their exit on each side and persist as three separate strands in the petiole of each cotyledon. At right angles to the cotyledons, two strands from the epicotyl leaves appear, one on each side. As these strands are traced through the hypocotyl they are seen to separate from one another, and on reaching the collet area where the parenchymatous system is large each xylem strand separates into two, three, or more parts. At the collet area I have counted as many as twenty-two groups of xylem resulting from the scattering of the original eight traces. Traced below the collet into the primary root a fusion occurs, but whether this takes place between parts of dissimilar bundles or otherwise is very difficult to determine. The fusion goes on gradually, and at certain levels the number of strands is seen to be sixteen, later twelve, and through eight and six on to a final four. In no species are there ever less than four strands in the apical portion of the primary root.

Owing to the highly scattered nature of the xylem elements it is often impossible to ascertain the exact area wherein the inversion of orientation is effected.

In seedlings of the same species there is a great variation; sometimes only one lateral cotyledonary trace undergoes division, sometimes all three; the epicotyledonary traces when present may remain compact, or each may separate into two or three strands. In a general way it may be stated that the type of xylem in the seedlings is one where a splitting is seen in any of the cotyledonary traces into two or

three portions, together with a prolongation of epicotyledonary strands to different distances in the primary root.

In seedlings where the epicotyledonary traces are not continued into the primary root a similar splitting of the xylem of each cotyledon trace may occur.

The presence of twelve to twenty-two xylem strands in a comparatively narrow cylinder, where each strand is relatively large, renders the actual behaviour of each strand difficult to follow.

The reason for such profuse scattering of the proto-xylem system is perhaps to be found in the bulky nature of the parenchymatous system. In all cases the scattered condition attains its maximum in the collet area where the parenchymatous system is at the maximum, and it would appear probable that the mechanical support and supply of nutrition were the objects aimed at. The splitting is always more complicated in a wide parenchymatous seedling, such as D. Embryopteris, than in a narrow one, such as D. Ebenum, and the fact that the strands are thus distributed prior to the appearance of a vascular cambium is sufficient proof that the diffuse condition of the proto-xylem is not due to the pressure of new cambial products.

### **Direction of Lignification and Differentiation of the Vascular Elements.**

If the embryo or young seedling be examined the differentiation of lignified elements can be determined. We may assume that lignification commences in the oldest element first and gradually appears in successively younger elements. *i.e.*, that the direction of differentiation of the elements is the same as that of lignification. In the embryo the beginning of lignification is seen in the xylem of the cotyledonary traces, and commencing at the cotyledonary node the lignified elements can be traced downwards into the primary root and upwards into the petiole of the cotyledons. The lignification at this stage is somewhat irregular, and appears to be a little

advanced in the median cotyledonary trace as compared with the laterals.

In the short axis of the embryo it is difficult to fix on the exact area at which lignification first appears. Examination of later stages shows the maximum lignification of the cotyledonary xylem at the collet area, and that the lignification subsequently spreads downwards into the primary root and upwards into the hypocotyl. The collet area is also the first to show a vascular cambium and the maximum parenchymatous system; it therefore appears to be the centre of activity of the seedling axis.

The fact that the lignification of the cotyledonary xylem reaches the maximum at the collet area may, however, still allow of the original starting point being at the cotyledonary node, and the enhanced lignification at the collet may be a secondary development associated with the requirements of the seedling subsequent to the purely embryonic stage. In the embryo the conducting systems are functioning in the conveyance of nutritive materials from the endosperm to the primary axis, and there does not therefore appear to be any necessity for lignification to commence at the collet area. There is the possibility that the direction of lignification may be purely responsive to the requirements of the seedlings, in which case no evidence can be obtained of the direction of differentiation of the original xylem elements.

The lignification is completed throughout the hypocotyl and primary root of the embryo within such a period, that prior to the apex of the primary root presenting itself at the micropyle a continuous series of lignified elements exist from root to cotyledons.

The epicotyledonary strands when present in the primary root show a definite direction of differentiation.

The phloem of each epicotyledonary strand begins at the epicotyl leaf and spreads downwards into the hypocotyl and root. This direction of differentiation is obviously the best,

since the function of the phloem strands is to conduct the materials prepared in the epicotyl leaves, together with the endosperm material absorbed through the epidermis of the young stem, to other parts of the seedling, viz., the hypocotyl and root.

The xylem of the epicotyledonary traces is, however, judging by the direction of lignification, differentiated in the opposite direction. This is obviously the best direction possible, as these tissues have to conduct the water from the root area to the epicotyl leaves, and since the cotyledons have become detached the sooner the xylem can be differentiated in the water-absorbing tissues the better.

The lignification of the epicotyledonary xylem usually reaches the cotyledonary node while the seedling is young and prior to the detachment of the cotyledons.

There is also another point in connection with the possible utility of the cotyledonary strands, which being disconnected from the cotyledons and endosperm seem likely to be in the way of any extra development of the epicotyledonary strands. The epicotyledonary traces remain separated from those of the cotyledons for a long time, but in D. Thwaitesii and probably in many others they become connected by the cambial products formed between the separate bundles. By this means the conducting power of the cotyledonary traces is tacked on to those of the epicotyledonary leaves and used in supplying the latter with the requisite food materials. This is therefore a good example of utilization of otherwise useless or abortive tissues during a phase of great urgency.

#### VI.—REPRODUCTIVE ORGANS. *M. 67-105.*

The production of flowers in Ceylon species of *Diospyros* is usually associated with that of leaves, and is therefore subject to many variations. In many trees of D. Gardneri, D. Embryopteris, and D. sylvatica the flowers immediately follow the new leaves, and since the latter appear more or less regularly every year, an annual production of flowers

may be said to occur. Often, however, a leaf production may take place without a corresponding one of flowers, this being particularly noticeable in young trees having more than one period of leaf production a year. Again, flowers often appear on old woody twigs independent of leaf production, or recur in the same position year after year, sometimes in the axil of an old persistent leaf, and at other times in the old axil of a fallen leaf. In many trees of D. Ebenum and D. Toposia the majority of the flowers occur in the axils of new leaves, and therefore appear mainly at one time of the year, but such copious productions of flowers are invariably preceded and followed by periods of minor floral activity when the flowers appear without any definite relation to the leaves.

It is therefore obvious that no generalizations can be made beyond stating that the greater part of the flower system usually makes its appearance immediately after a copious production of leaves. The importance of realizing the irregular nature of leaf and flower production is great, and one cannot lay too much stress on the fact that in the forests of Ceylon the species of *Diospyros* have not one fixed time of the year for flower production. In the Sabaragamuwa districts there is not a month in the year when trees of D. insignis and D. hirsuta are absolutely flowerless, and the fact that trees of the same species growing alongside each other may possess either flower buds, mature flowers, ripe fruits, or no reproductive organs whatever during the same month, is sufficient to allow one to dispute any hypothesis based on the idea of a general seasonal periodicity.

It may be further stated that many *Diospyros* trees probably remain flowerless for many years at a time, and the appearance of sexual organs cannot be correlated with the prevailing seasons. This was the opinion of Thwaites and Trimen, and most forest officers still firmly believe that the majority of Ceylon *Diospyros* trees flower but seldom.



There are no records of careful observations made upon particular trees for many years in succession, and though the writer is prepared to admit the probability of the above contention, experience in the forests has led him to believe that the production of flowers in Ceylon *Diospyros* trees is by no means a rare occurrence. The great size of the trees, the inconspicuous nature of the flowers, and the uninhabitable districts in which many of our species occur, have led most people to believe that flower production is much rarer than it really is. We may, however, safely say that there is much irregularity in flower production, and the phenomenon can only be explained by a study of the individual equation of the plant we are dealing with.

*Age of Flowering Trees.*—In the absence of precise information on the rates of growth of tropical trees we can best state our ideas under this heading in terms of cauline dimensions. The majority of our dry zone species, particularly *D. Embryopteris* and *D. ovalifolia*, do not flower until the trees have attained considerable dimensions. Specimens of the former having a circumference of 3 feet and of the latter over 1 foot in girth are now growing at Peradeniya, but have not yet flowered. One specimen of *D. quæsita*, having a breast-height circumference of 47 cm. ( $18\frac{1}{2}$  inches) and known to be over sixty years old, has not yet flowered at Peradeniya. Trees of *D. Ebenum*, *D. affinis*, and *D. Gardneri* are known to repeatedly flower at Peradeniya, and have a breast-height circumference varying from 38 to 50 cm. ( $15$  to  $19\frac{1}{2}$  inches).

On the other hand, trees of *D. hirsuta* and *D. Thwaitesii* in their native habitat flower when their stems have a diameter of 4 to 6 inches; *D. pruriens* may flower when the dimensions are still less, and trees of *D. acuta* and *D. attenuata* have been seen in flower when the diameter of their stems has not exceeded 25 mm. (1 inch). The following table is given with a view to elicit more precise

information in the future, and the dimensions quoted have been determined personally in the districts mentioned:—

Minimum Dimensions of Flowering Trees.

Name.	Locality.	Breast-height Diameter of Stem in Mm.
<i>D. Embryopteris</i>	... Peradeniya	... 155
<i>D. affinis</i>	... Bibile	... 130
<i>D. oocarpa</i>	... Kalugala	... 180
<i>D. Ebenum</i>	... Pindeniya	... 125
<i>D. montana</i>	... Madawachchi	... 75
<i>D. quæsita</i>	... Karawita	... 250
<i>D. crumenata</i>	... Hantane	... 260
<i>D. Toposia</i>	... Gammaduwa	... 60
<i>D. Gardneri</i>	... Hantane	... 120
<i>D. hirsuta</i>	... Ratnapura	... 65
<i>D. Moonii</i>	... Yagirilla	... 25
<i>D. Thwaitesii</i>	... Hewessa	... 100
<i>D. oppositifolia</i>	... Hiniduma	... 50
<i>D. attenuata</i>	... { Pasdun korale, near Hiniduma }	... 25
<i>D. sylvatica</i>	... Hantane	... 250
<i>D. acuta</i>	... { Pasdun korale, near Hiniduma }	... 25
<i>D. Melanoxyton</i>	... Bibile	... 110
<i>D. pruriens</i>	... Kadawatta	... 60
<i>D. insignis</i>	... Ratnapura	... 60
<i>D. ovalifolia</i>	... Kanthalai	... 200

20) 2325  
116 1/2 mm

*Position of Flowers.*—The majority of the flowers, whether solitary or in the form of an inflorescence, appear in the axils of foliage leaves, and are therefore most usually found near the ends of the ultimate twigs. Many species, however, have their flowers disposed on old twigs or branches, this being characteristic for *D. Moonii*, *D. ovalifolia*, and *D. insignis* in particular.

When the flowers are monœcious the females usually appear in the axil of the youngest leaves and the males in the axil of lower leaves. In *D. oppositifolia* and *D. acuta* a female flower usually terminates each young shoot; other female flowers occur in the axils of young leaves, but the males occur either in the axil of old leaves, or on woody twigs independent of foliage leaves. The females are thus subject to more exposure, and being exposed to the wind on all sides are more likely to attract insects and to catch wind-borne pollen.

*Nature of Flower System.*—The nature of the flower system varies with the species and with the sex of the same species. The flowers may be solitary, pedunculate, or sessile, or in the form of an inflorescence having each member supported on a pedicel of varying length. When the peduncle and each lateral pedicel of a cymose inflorescence is very short the flowers form what may be conveniently described as a sessile cluster. The male and female flowers may each form inflorescences; here both inflorescences may be in the form of sessile clusters, as in D. insignis, both inflorescences may have pedicellate flowers, as in D. Embryopteris, or the members of the female inflorescence may be sessile and the males shortly pedicellate, as occasionally occurs in D. Ebenum.

On the other hand, the females may occur solitary and the males as an inflorescence; under this group we may have the female flower and each male flower markedly pedicellate, as in D. quæsitæ, or both sessile, as in D. Gardneri; we may also have the female sessile, but males pedicellate, as in D. Melanoxylon, or the female pedicellate and the males sessile, as in D. oppositifolia.

### **Female Flowers.**

In fourteen out of our twenty species the female flowers may occur solitary; in nine of these, viz., D. affinis, D. pruriens, D. oppositifolia, D. quæsitæ, D. sylvatica, D. crumenata, D. Toposia, D. oocarpa, and D. montana, the flower is on a peduncle of varying length, whereas in the remaining five, D. ovalifolia, D. Melanoxylon, D. Gardneri, D. attenuata, and D. Ebenum, the female flowers are sessile.

In the remaining six species the female flowers form an inflorescence which in D. hirsuta, D. insignis, D. Moonii, D. Thwaitesii, and D. acuta is a sessile cluster of three to fifteen flowers; but in D. Embryopteris the inflorescence is a cyme of three flowers, each of which is attached to the short peduncle by means of a short stout pedicel.

It must here be stated that the female flowers of D. acuta, D. sylvatica, and D. Ebenum may occur in the solitary or grouped condition on the same tree. It now remains for us to study the relationships between the parts of a solitary female flower and the members of a female inflorescence.

*Development of the Female Flowers in D. Gardneri, D. Embryopteris, and others.*—In D. Gardneri the pubescent flower bud arises in the axil of a new or old foliage leaf. The peduncle is very short and rarely exceeds 0.4 cm. in length, but very soon two small leaves appear at right angles to the antero-posterior axis. In addition to these a third leaf may appear between the normal foliage leaf and the anterior side of the flower, and this may be followed by a fourth on the opposite side between the axis and the posterior side of the flower. Under ordinary circumstances, and even if the flowers be cut away so as not to greatly disturb surrounding organs, no development takes place in either of the bracts numbered 1, 2, 3, and 4. If, however, we now study the development of the female inflorescence in D. Embryopteris, we find exactly the same sequence of events, but in addition a flower bud appears in the axil of each of the small leaves on the primary peduncle (pl. IX., figs. 7-10). Similarly with the female inflorescences of other species. It is further to be noted that when the female inflorescence forms a sessile cluster the appearance of each flower is always preceded by that of the small leaf, and in many of them a considerable amount of abortion occurs.

Often in D. Thwaitesii there is a solitary female flower surrounded at the base by an involucre of bracts, abortion having occurred in the axil of the lower bracts. We may therefore arrange the female flower systems in one series to show that the solitary flower arrangement is probably derived from the cymose inflorescence by abortion in the axil of the lower bracts. This is the most likely course of evolution, since the lateral flowers in the inflorescence of D. Embryopteris often drop before they reach maturity in consequence of the pressure exerted by the quickly growing median flower.

### Male Flowers.

In every Ceylon species the male flowers occur in clusters of three or more individuals ; in D. attenuata and D. oppositifolia they may also occur solitary in the axil of the younger leaves. Sometimes the cluster of flowers is inconspicuous, as in D. attenuata, but at other times, particularly with D. sylvatica, D. quæsitæ, and D. Toposia, a single inflorescence may have a height of 50 mm.

The peduncle or the central flower of an inflorescence arises in the axil of a young leaf, which may be of the normal type or greatly reduced ; similarly with each lateral flower or its pedicel. When the individual flowers of a cluster are sessile there is often a great deal of abortion, and the remaining flowers therefore appear surrounded with very many bracts, so that a rudimentary involucre is formed.

The types of male inflorescences are three in number. In the first class we have the primary peduncle and the pedicel of each lateral flower so small as to be undistinguishable to the naked eye, and the inflorescence may therefore be described as a sessile cluster, as in D. ovalifolia, D. hirsuta, D. Moonii, D. insignis, D. Thwaitesii, D. oppositifolia, D. attenuata, D. acuta, and D. Gardneri. In the second class we have each flower disposed on a very short pedicel from 1 to 5 mm. in length, as in D. oocarpa and D. sylvatica. In the third class we have the remaining nine species, in each of which the flowers are supported on very long pedicels often considerably over 10 mm. in length.

*Development of the Male Inflorescence.*—It will be better to first detail the developmental phases of an inflorescence of the third type, and no better species can be chosen than D. Embryopteris. In the earliest stages the inflorescence appears as a globular apiculate axillary structure, supported on a short stout peduncle and covered by a varying number (two to five) of regularly arranged bracts. As the inflorescence gradually opens, the first pair of bracts are seen to be opposite or subopposite and disposed one on either side, at

right angles to the antero-posterior axis ; these are the first to drop, and each possesses in its axil a semilunar pedicellate flower. Each lateral flower is in close contact with the median flower, which is always the largest and the oldest (pl. IX., figs. 1-4).

A second pair of bracts is seen in the early stages, arranged one on each side at right angles to the first pair, but at different levels ; each of these likewise possesses a small pedicellate flower in its axil. At a much later stage, some time after the fall of the first two bracts, a fifth bract appears between the median flower and the third lateral flower, and in its axil a shortly pedicellate flower arises.

In point of time the median flower arising in the axil-of a foliage leaf is not much in advance of the first pair of lateral flowers. The third flower does not, however, appear for some time, and the interval of time between its appearance and the next flower, with which it forms a subopposite pair, is still more prolonged. The appearance of the fifth lateral flower is considerably delayed, and often it does not appear until the majority of the bracts of the other flowers have dropped. We therefore see that the interval of time between the appearance of successive flowers of the same inflorescence increases gradually, and the flowers do not cease to appear until the oldest individuals have undergone considerable expansion and their subtending bracts have dropped.

We thus obtain finally a definite inflorescence having the terminal flower the oldest, but the youngest flower next to it, the development of each lateral flower being to the median centrifugal, but to one another centripetal. (See pl. IX., fig. 5.)

If we now compare the development of the male inflorescence of any other species, approximately the same phases are passed through. In some species the number of lateral flowers is small, as in *D. pruriens*, whereas other species, notably *D. Toposia* and *D. sylvatica*, have a much more complicated system of flowers, in consequence of each lateral

pedicel becoming the main peduncle of another cyme. (See pl. X., figs. 7-8.)

It is obvious from the descriptions given that the inflorescences of the male and female are similar in their phases of development, the only difference being one of degree, since the female more often than not consists of a single flower having a pair of bracts at right angles to the antero-posterior axis, or with two to four bracts along its peduncle. The solitary female flower with its concomitant structures is an exact representation of the early stages of the complex inflorescence of the male. It is quite probable that the whole of the Ceylon species of *Diospyros* can be traced back to a type of reproductive organs in which the flowers of an inflorescence were numerous and hermaphrodite.

*Variation.*—Though the solitary flower or inflorescence is fairly constant for the sex of the species, it is not by any means strictly so. The female flower, though occurring solitary in the majority of our species, is liable to be replaced by a simple dichasial cyme. This is particularly frequent in *D. acuta*, *D. sylvatica*, and *D. Ebenum*, and it is probably only a question of further observation to establish the same tendency on the part of the female flower in other species.

The variation on the male side is much more conspicuous. In *D. oppositifolia*, for instance, instead of a male inflorescence of many flowers, there may be a solitary male flower; in *D. Toposia* we may observe every variation from a single flower to a complex inflorescence of eighteen flowers.

This variation on the male side is not of any serious consequence to the plant, since the number of male flowers is always greatly in excess of the female. On an average there are about six times as many male flowers as female flowers in monœcious species, and probably a still greater proportion of males in those species which are not monœcious; hence, in the general characters of the inflorescence and individual flowers there is considerably more variation on the male than on the female side.

### Sex.

According to Hiern the genus *Diospyros* is characterized by dioecious flowers, and only rarely is a polygamous or monœcious state to be observed. It is further stated that when such departures from the dioecious condition do occur they do so only casually, and one is left to infer that the variation is one to be explained on individual grounds and is not of specific importance.

Including species imperfectly known, Hiern describes 170, and of these only 7 per cent. are recorded by himself or others as showing a departure from the dioecious condition.

Accordingly, Hiern formed a classification for the whole of the Ebenaceæ, showing the genus *Royena*, L., with hermaphrodite or rarely subdioecious flowers and the remaining genera, viz., *Euclea*, Linn., *Maba*, Forst., *Diospyros*, L., and *Tetracelis*, *gen. nov.*, with dioecious or rarely polygamous flowers.

Confining ourselves to the Ceylon representatives of *Diospyros*, we find that Thwaites and Trimen believed the genus to be characterized by dioecious flowers, and that the flowers were only very rarely monœcious. Thwaites noted the departure from the dioecious condition in two of our species, and stated that in *D. acuta* the flowers were sometimes monœcious, and that in *D. hirsuta* the female flowers are sometimes intermixed with the male.

The main source of error has probably been in that the material at hand has not been very abundant, or the examination has been made upon herbarium specimens or material which had been collected some time previously. In the so-called "male" flowers of *D. Gardneri* there is very little external character indicative of a fertile pistil in the fresh material, and it is only by continued observation that ripe fruits may be seen.

Herbarium specimens of known hermaphrodite and polygamous flowers of *D. affinis*, *D. hirsuta*, and others do not show any prominent external differences from known male



flowers of the same species, and it is only by actual observation of fresh material in the forest that the true sex has been determined. It has been the common experience of myself and many others to regard trees of D. sylvatica and D. Gardneri as males, until they have been felled, when in addition to flowers possessing fertile stamens, abundance of ripe fruits have been obtained on the same branch. In order to further emphasize this condition I may say that the whole of the anatomy and development of seedlings of D. sylvatica, to be published elsewhere, was first worked out from seeds obtained from a tree which has for many years been labelled as a "male," and from which material for sketching the "male" inflorescence has been derived.

From the following notes it will be seen that examination of fresh material in the forest has shown that there is a departure from the dioecious condition in ten out of our twenty species. Speaking generally, the sex appears to be very unstable, the dioecious, monœcious, polygamous, and hermaphrodite conditions having been found. The occurrence of hermaphrodite flowers resulting in a polygamous condition is so frequent that there is every reason to doubt their non-existence in any of the Ceylon species, providing sufficient material can be examined outside the herbarium.

It may be further stated that specimens of D. Thwaitesii have been repeatedly examined, which suggested that the sex of the flower might vary from time to time; this has been described for other plants.\* Certain it is that the sex of the flower often exhibits every variation in the same inflorescence of D. sylvatica, and the many stages observed readily allow one to form a series having staminate flowers at one end and hermaphrodite at the other.

The types of flowers characteristic for the different Ceylon species may now be described under the following headings: (a) dioecious only, (b) monœcious only, (c) dioecious and polygamous, and (d) dioecious, monœcious, and polygamous.

\* Willis, Gynodioecism, &c. (3rd paper); Proc. Camb. Phil. Soc., 1893.

*Diœcious only*.—This condition prevails in D. Toposia, D. quæsita, D. pruriens, D. crumenata, D. ovalifolia, D. Melanoxylon, D. attenuata, D. montana, D. Moonii, and D. oocarpa.

In these species the female flowers may be solitary or form a simple or complex dichasium, having the staminodes of each flower with barren anthers. The males may form a cymose inflorescence, sessile or otherwise, in each flower of which the pistil is absent, rudimentary or represented by a bunch of hairs. It is highly probable that if more fresh material is examined at least the polygamous and very possible the monœcious condition will be observed. In many of the species included under this head the male flowers are always very numerous, often as many as fifteen to each inflorescence, and hence the possibility of variation and occurrence of polygamy. In some of the species, notably D. quæsita and D. Toposia, the rudimentary pistil of many male flowers is often of conspicuous size, and a transverse section reveals the presence of irregularly outlined cavities. Further, it is not unlikely that if the staminodes of the female flowers be examined fresh they will yield pollen grains. Very little material has been examined microscopically from this point of view.

The number of members in the staminal whorl and their orientation in the male and female flowers of the same species is sometimes widely different; for instance, in D. quæsita the female flower possesses five staminodes which alternate with the corolla lobes, whereas in the male flowers an indefinite number of stamens occur clustered together in the centre of the flower, and have no individual orientation to one another or to the members of other whorls. Similarly, great differences exist in the staminal whorl of D. pruriens.

In D. Melanoxylon the staminal whorl is very unstable in both sexes, there being ten, sixteen, or twenty stamens in the male, sometimes with the filaments free, at other times united in pairs, and twelve or more staminodes in the female flower having no fixed orientation to the four- to seven-lobed accessory whorls.

*Monœcious only.*—This occurs in D. oppositifolia and D. acuta.

In D. oppositifolia the female flower is usually solitary and at the end of a young twig. Occasionally a female flower occurs lower down in the axil of old or young leaves. When the flower terminates the young shoot it is usually on a peduncle from 5 to 20 mm. long; when in the axil of a leaf it is invariably sessile and mixed with male flowers. The staminodes are usually four in number, alternating with the corolla segments; or exceptionally eight in number, opposite and alternate with the corolla segments. In every case examined the anthers of the staminodes were barren. The male flowers occur in sessile or subsessile inflorescences in the axil of old leaves or on old twigs. Each flower possesses eight stamens and a rudimentary apical mass of long unicellular hairs in the position of the pistil of other flowers. The stamens are usually paired, the pairs usually alternating with the corolla segments. The resemblance between the orientation of the staminal whorl of the female flower and that of the stamens of the male flower is here very great, and as far as this whorl is concerned we may speak of the flowers as male or female, according to the fertile or barren condition of the anthers. cf. post p. 84

D. acuta, according to Thwaites, is occasionally monœcious; personally I have never been able to obtain any other condition, though I found it in abundance at Wewella, Weerakanda, Hewessa, and Pasdun korale. The male and female flowers occur in clusters in the axil of old or young leaves, the individuals of the same cluster being of the same sex. As in D. oppositifolia, the female flowers occur mainly in the axil of the younger leaves, the male flowers being below. In the number and orientation of the members of the staminal whorl there is a tendency to variability on the male side. In the male flowers there may be five, seven, or nine epipetalous stamens, usually separate but occasionally united in pairs, and when the latter condition obtains the inner cf. post p. 84

stamen of a pair is very small and contains very little, if any, pollen when mature.

On the other hand, the staminodes of each female flower are always five in number, epipetalous, and arranged so as to alternate with the corolla segments.

It is therefore to be noted that in the species which are monœcious only the staminodes are constant in position and number, the stamens may equal or double the staminodes in number, and a rudimentary pistil usually occurs in the centre of each male flower. As to whether the male flower can be derived from the female, or *vice versâ*, by sterilization of sporogenous tissue, nothing need be said in this part of the paper.

*Diœcious and Polygamous.*—This occurs in D. sylvatica, D. Gardneri, D. affinis, D. Embryopteris, and D. insignis.

Under this section we must differentiate between the polygamous condition due to replacement of a staminode by a stamen, as in D. Embryopteris, and that due to the pistil of a male flower exerting its potentiality, as in D. affinis, D. sylvatica, and D. Gardneri.

In D. Embryopteris we have the distinct male and female forms, and the species can be said to be diœcious. The female flowers have four staminodes\* alternating with the corolla lobes and a central pistil having an eight-celled ovary. The male flowers have an indefinite number of stamens and a rudimentary pistil. It has, however, been noted by Hiern that the staminodes of the female flower may be replaced by perfect stamens, thus giving rise to a polygamous state. The male flowers of the same species likewise show an occasional fertile pistil, resulting in a polygamous condition on the same tree.

In D. sylvatica, D. Gardneri, D. insignis, and D. affinis we have the diœcious and polygamous conditions well

\* Hiern states (p. 258) that D. Embryopteris has one to twelve staminodes in the female flower.

demonstrated. The conditions are the same for each of these species, and a description of one will therefore be sufficient.

Selecting *D. sylvatica*, we find that in this species we have three kinds of trees, viz., (a) female trees, (b) male trees, and (c) polygamous trees.

The female trees have their flowers arranged either solitary or in simple cymes, each component having four or eight staminodes and a six- to eight-celled ovary. The calyx is usually accrescent and larger than that of the male.

The male trees have dense cymes, each often with fifteen flowers. Each male flower possesses an indefinite number of stamens and thin calyx segments.

The polygamous trees have the flowers arranged as in a male cyme, and among them three types of flowers can be distinguished. In the first section we have hermaphrodite flowers, each of which is characterized by large accessory whorls, twenty-two stamens, and a fertile pistil. The fruits from these flowers possess seeds which in the characters of the testa and embryo exactly agree with those from known female trees. In the second class we have flowers with large accessory whorls, twenty-two stamens, and an abortive pistil showing an ovary one- to six-celled. These never yield good fruits. In the third class we have flowers with small accessory whorls, twenty-two stamens, and an abortive pistil.

It is therefore clear that in the polygamous trees we can obtain every stage from purely staminate to hermaphrodite flowers.

It must not be supposed that the polygamous condition may occur on any tree. There are male trees which never produce anything but staminate flowers and female trees which never possess stamens, and these must be clearly distinguished from those trees showing the polygamous condition.

The difference between the indefinite staminal whorl of the male and polygamous flowers and that of the true female

is very great, and though it is easy to connect the flowers of the third class in the polygamous group with those of the true male, it is not so easy to connect the hermaphrodite flowers of the polygamous group with the ordinary female flowers.

We have again to realize that in the same species there is a wide variation in the number and orientation of the floral parts of male and female flowers.

*Diœcious, Monœcious, and Polygamous.*—This may occur in flowers of *D. hirsuta*, *D. Thwaitesii*, and *D. Ebenum*.

In these species a very complicated sex relationship exists. If we take as our example *D. Thwaitesii*, we find that three types of trees exist.

In the first place there are pure female trees. Here the flowers may occur solitary or in small sessile axillary clusters of two to seven flowers, each component having five staminodes disposed so as to alternate with the five lobes of the corolla and a four-celled ovary.

In the second class there are pure male trees having the flowers in axillary groups of four to fifteen. Each flower has ten stamens arranged in five pairs alternating with the corolla lobes, or several pairs and the remainder single, arranged irregularly or as five series. In these flowers the pistil is always rudimentary, and consists of nothing more than a central mass of brown hairs. It is in the third class of trees that complicated relations exist. In this class we have the true male and true female flowers occurring on the same tree, sometimes in separate axillary groups of the same branch, and at other times in the same axillary group. Thwaites noted that in *D. hirsuta* the female flowers were sometimes mixed with the male. We may therefore speak of the monœcious condition in these species. But in addition to the monœcious condition we may have on the same tree a truly polygamous group or groups of flowers exactly analogous to the polygamous flowers described for *D. Gardneri*, *D. sylvatica*, and others. The polygamous

condition is where each flower has ten or more stamens, each with a perfect anther and occasionally a central pistil which ripens into fruit.

It is obvious that a distinct correlation can be established in the number and position of the members of the flowers borne on trees of this class, and since the occurrence is so irregular and the stages established include the male, hermaphrodite, and female conditions, some light may be thrown on the evolution of sex in this genus.

In considering the relations between the members of the flowers on trees of the third class we may at once eliminate the calyx and corolla, since in all the flowers the variation is only one of size, the maximum and minimum dimensions being in the female and male flowers respectively.

The staminal whorl in the male flowers, whether these form a separate cluster or part of a monœcious or polygamous group, consists usually of ten stamens arranged as five pairs, alternating with the corolla segments. In some male flowers there may be only eight stamens arranged as three pairs and two separate individuals, and in others I have met with an irregular epipetalous group of stamens. In the female flowers, no matter where they occur, the staminal whorl is represented by five epipetalous staminodes disposed so as to be alternate with the corolla lobes. The position of the members of the staminal whorl in male and female flowers is approximately the same, and the five single staminodes of the female can be connected with the five groups of stamens usually existing in the male flowers. Since the staminode is really a stamen having a barren anther, we therefore see that the difference between the male and female flowers can be easily accounted for, assuming there has been abortion of sporogenous tissue.

In the gynœcium the number of loculi in the ovary and the number and position of the ovules and seeds is the same, whether the pistil is part of a hermaphrodite or female flower.

It is therefore possible to make a complete series from flowers on the same tree, having staminate flowers at one end, passing through hermaphrodite to female flowers.

In other trees of the same species the sex is either male or female and is fixed.

*cf. p. 99.*  
D. Ebenum is included under this heading, and though the dioecious condition is the most common form for this species, yet observation of fresh material in the forest has revealed the frequent occurrence of the monœcious and polygamous state. The monœcious state consists of female flowers often ripening into good fruit on a pedicel in a male inflorescence. The monœcious condition in D. Ebenum is unlike that in D. oppositifolia or D. acuta, since the female flowers do not occur solitary but as sporadic members of a male cyme. On first examining such a monœcious inflorescence the thought uppermost in my mind was that here we were dealing with a male inflorescence, some members of which had reverted to the condition of a potential gynæcium, but this idea was abandoned in consequence of the fact that each of the female flowers when thus occurring possessed eight staminodes each with a barren anther, and an eight-celled ovary. We therefore have true female flowers occurring in the same cluster as the males.

The female flowers may occur in any part of the inflorescence, but the most usual position is that terminating the inflorescence and therefore occupying the central position. Since the central flower is the first formed we therefore obtain a time relation in the production of sex, the female flowers being produced first and the male flowers afterwards.

*cf. anti p. 79.*  
The production of female flowers in the axil of the youngest leaves, and that of the males in the older leaves in D. acuta and D. oppositifolia is a sequence to be correlated with this.

In consequence of the complex relationships in species described it is well to realize that the monœcious state in



D. Ebenum is due to the interpolation of a female flower in a male cyme. The female flower when thus occurring presents no differences from the female flower of dioecious trees, except in that it is pedicellate. In no case have I met with the monœcious form due to the replacement of a female flower by a male.

The occurrence of true male and female flowers in the same inflorescence is of importance, since the characters of the accessory and essential whorls in the male and female are often so widely different. It has been suggested by many observers that since the flowers, the habit, and foliage of what are regarded as the male and female trees of the same species often show great differences, we might be erroneously considering male and female trees of what are really separate species as being of the same species. Subsequent observations demonstrated the frequent occurrence of polygamy, and for a time these gave support to the above contention. Now, however, we have seen that the true male and true female flowers possessing different types of accessory and essential whorls can occur in the same inflorescence, and we can therefore adhere to the former ideas as to the true dioecious form of some species.

### **Characters of Accessory and Essential Whorls.**

*Calyx*.—The calyx is always inferior and gamosepalous; sometimes glabrous or nearly so, as in D. sylvatica, at other times densely pubescent, as in D. Embryopteris and D. pruriens.

In the male flowers the calyx segments are relatively small and accrescent, whereas in the female and hermaphrodite flowers they attain considerable dimensions and the segments project outwards.

In the Ceylon species the calyx segments are usually very distinct, varying in number from two to seven; the common number of segments is four or five. In some species, however, the calyx segments cannot be distinguished, as in D.

*oocarpa*; in *D. Toposia* the calyx of the male flower is closed in the bud, and bursts irregularly into two or more segments when the flower opens. The calyx segments are most strongly marked in *D. Embryopteris*, *D. Ebenum*, *D. Gardneri*, &c., but in many of the species belonging to this class the conspicuousness of the calyx segments becomes reduced during the development of the fruit.

The calyces of the female and hermaphrodite flowers can be divided into several classes, the first comprising those which even after fruiting remain small, thin, and horizontal, as in *D. pruriens*, *D. montana*, *D. sylvatica*, *D. attenuata*, *D. oocarpa*, and others, the second class comprising those which, though they have undergone considerable enlargement during the formation of the fruit, remain relatively thin and horizontal, as in *D. Moonii* and *D. hirsuta*, the third those which increase considerably in size and form a shallow or deep cup in which the ripe fruit is lodged, as in *D. Gardneri*, *D. oppositifolia*, *D. affinis*, *D. quæsita*, *D. insignis*, and many others.

During the formation of the fruit the calyces of the third class show different courses of development. The most usual is to form a very large intersegmental pouch and pointed apices, together with a feeble reflex margin; this is best seen in *D. quæsita*; in other species, notably *D. Ebenum*, the apices become strongly pointed and horizontal and the margin strongly reflexed; in *D. insignis* and *D. crumenata* the enlarged woody calyx becomes strongly four-sided in consequence of the dying back of the apices of the segments and the very reflex nature of their margins.

Many of the calyces, though highly pubescent in the flower stage, become glabrous in the fruiting stage. The hairs, with one exception, are long unicellular outgrowths from single cells. In *D. Ebenum*, however, the base of the shallow calyx cup is covered with unicellular and pedicellate hairs, the latter having very much the appearance of globular multicellular glands supported on pedicels of

varying length. I have not met with these multicellular glands on the calyx of any other species, though they occur abundantly over the carpellary wall of D. Embryopteris (pl. XIX., figs. 10-11). *cf. p. 94.*

The calyx usually persists on the ripe fruits, but in many of those which form deep cups the fruits seem to become detached and the calyx is left on the twig.

The general characters of the calyx segments and the ferrugineous hairs with which they are very often coloured are, according to Hallier,\* of systematic importance and comparable to similar structures in the Pittosporaceæ.

The same botanist† also calls attention to the fact that in Scytotetalum the segments of the small calyx cannot be distinguished, and suggests an affinity with the Ebenaceæ. We have seen that in D. oocarpa particularly, and also to a less marked extent in D. Toposia, the calyx segments are often undistinguishable. *pl. 85-86*

*Corolla.*—The segments are united and usually, though by no means always, isomerous with those of the calyx. The colour is yellow, white, or greenish. The tube and segments are often covered with silky or brown hairs, sometimes on the outside only, at other times on both sides. The margin of the segments in species like D. hirsuta is very hairy. The segments are usually equal, and according to Hiern‡ are contorted sinistrorsely in æstivation as regarded from inside, except D. oocarpa, in which the æstivation is variously imbricated. The corolla is occasionally very conspicuous, as in D. Embryopteris and D. Ebenum, but most usually is small and unattractive, as in D. Toposia and D. attenuata. The segments may be relatively long, as in D. pruriens, or very short as in D. Toposia.

For convenience we will distinguish two types of corolla. The first type comprises all those in which the corolla

\* Hallier, *l.c.*, p. 33.

† Hallier, *l.c.*, p. 36.

‡ Hiern, *l.c.*, p. 60.

is widely open, as in D. Embryopteris and the urceolate flowers of D. sylvatica, the second all those in which the corolla tube communicates with the exterior by a very small aperture. The majority of the species have the corolla of male and female flowers of this type, and in many of them the aperture is exceedingly narrow and appears to be closed until a late stage in the development of the flower. The smallest apertures are to be seen in D. attenuata, D. quæsitæ, and D. Toposia.

The smallness of the aperture renders it impossible for any but the smallest insects to enter them, and this, together with the inconspicuous nature of the flowers in general, may yet be found to be correlated with the evolution of sex in this genus.

The sympetalous corolla with imbricated æstivation reminds one of the Styracæ, Sapotacæ, and Ilicinæ\*. It is also true that the corolla segments are often deeply partitioned, and that such bear a resemblance to polypetalous orders.

Hallier† lays stress upon the fact that the corolla segments are alternate with the five small, narrow and acuminate calyx segments in Pittosporacæ and the Ebenales. This cannot be seriously regarded as of great importance, though one cannot but admit that the accessory whorls of, say, Pittosporum Timorense, Bl., have a strong resemblance in form, colour, and texture to those of the male flowers of Diospyros species.

*Staminal Whorl*.—The staminal whorl is in the form of an epipetalous, hypogynous, or perigynous ring of stamens or staminodes in the male and female flowers respectively; it is present in the flowers of every Ceylon species of Diospyros, and as an essential whorl is characteristic of the genus throughout the world.

The components of the staminal whorl have a much more constant orientation and number in the female than in the

\* Hiern, *l.c.*, p. 62.

† Hallier, *l.c.*, p. 33.

male flowers, and it is not always easy to correlate the members in the different sexes of the same species. The relation between the male and female staminal whorl is sometimes very simple, as in D. hirsuta, where there are five staminal organs in each male and female flower disposed so as to alternate with the corolla lobes. In the majority of Ceylon species, however, the staminodes of the female flowers are much fewer than the stamens in the male, a typical instance of which is seen in D. sylvatica, the male flowers of which have from thirteen to twenty stamens and the female flowers only four staminodes. The staminal whorl is of great interest, and since we have for the first time a complete collection of male and female flowers of every Ceylon species of *Diospyros*, a detailed account is here given.

*The Staminal Whorl of the Male Flowers.*—In every species of Ceylon *Diospyros* the male flower possesses many perfect stamens. These occur either as an epipetalous ring having a definite or indefinite orientation to the accessory whorls, or as a central hypogynous group; sometimes both conditions are observed in the same flower.

The filament is white or yellow and varies in length from 0.25 to 0.35 mm.; it is perfectly glabrous in some species, e.g., D. acuta and D. affinis, and densely pubescent in others, e.g., D. oppositifolia and D. Embryopteris.

The anther is usually brown in colour and when mature measures from 0.2 to 0.3 mm. in length; sometimes it is strongly apiculate in consequence of the presence of a large number of unicellular hairs which seem to have a duty to perform in the dissemination of pollen; at other times it is perfectly glabrous. Each anther is lanceolate-linear in shape, erect, two-celled, and dehisces by two longitudinal slits.

It is characteristic of the stamens in the majority of the male flowers to exhibit fusion; sometimes the filaments are united throughout their lengths, at other times only for a short distance. In the case of D. hirsuta there are five (cf. p. 97). separate stamens alternating with the corolla lobes; in D.

Gardneri the numerous stamens are arranged in pairs, the inner stamen of each pair having a shorter filament united throughout to the filament of the outer stamen; in D. Ebenum the stamens are united to form groups of three or four, the filament of the individuals of each group being united in the basal part, and therefore attached to the corolla as a single column; in D. pruriens the fusion has gone to such an extent that a single column formed by the fusion of the filaments of twelve or more stamens exists, similar to what occurs in the Malvaceæ. The importance of these stages in the fusion of the stamens when numerous will be discussed later.

We will now describe the types of male staminal whorls met with in Ceylon species.

(a) The simplest type is that in which the stamens are few in number and disposed so as to be in definite orientation to the members of other whorls. This is seen in D. hirsuta and D. Moonii, where each male flower possesses five epipetalous stamens alternating with the corolla lobes.

(b) A slightly more complex type is where the number of stamens is in excess of the members of any other whorl and their orientation becomes variable. In D. oppositifolia there are eight stamens usually arranged as four pairs alternating with the four corolla lobes. The members of each pair are separate from one another throughout their length, and a variation occurs when the members of one or more pairs become relatively widely separated. In D. acuta there may be only five stamens alternating with the corolla lobes, or there may be seven or nine, in which case some of the number may be single and the remainder as pairs with fused filaments. In D. Gardneri the complexity is increased, since there may be from six to eight pairs of stamens definitely orientated to the corolla lobes, or a monadelphous ring of stamens may occur.

(c) The next type is where the number of stamens is very large and no orientation to other whorls can be distinguished. In D. Embryopteris the male flower may possess from

twenty to forty stamens arranged to form an epipetalous ring, a hypogynous group, or part epipetalous and the remainder hypogynous. The stamens are nearly equal in length and occasionally the filaments are fused at the base. In D. Toposia there are from eighteen to thirty-four stamens of unequal length usually forming a hypogynous central group. In D. Melanoxylon there may be from ten to twenty stamens usually paired and forming a hypogynous group terminating the receptacle. In one flower there were thirteen stamens arranged as five pairs, each having the inner stamen shorter than the outer one, one pair with individuals of equal length, and one long stamen separate from all others.

In another flower of the same species there were fifteen stamens arranged in two whorls, the outer with eight and the inner with seven members. In the outer whorl four were arranged as two adjacent pairs and the remaining four as separate successive stamens; the inner whorl consisted of two united at the filament and the remaining seven separate.

In all those cases where there is an outer and inner whorl the stamens of the inner whorl are always shorter than those of the outer, the difference in length being usually in the filament.

In the male flowers of D. Ebenum similar variations may be noted in the number and position of the stamens. The number varies from about sixteen to thirty-five, but in the majority of flowers examined they are arranged as eight groups, each group having two, three, or four anthers supported on filaments of varying length. These eight groups are usually epipetalous and arranged opposite to and alternate with the corolla lobes. If we take one group of four stamens, we find it to be composed of a basal pedicel 0.1 cm. long, and bearing at this level two lateral, fertile, sessile anthers; above this level a third anther disposed introrsely is given off, and on the continued filament above this level is the fourth anther, always the outermost and disposed introrsely. The total length of such a stamina (

group is often over 5 mm. In one flower there were six groups each with four stamens ; and two groups each with two.

(d) In the last class we may include all those species the male flowers of which have numerous stamens united to form a central hypogynous column. This is typified in the staminal whorl of D. pruriens. According to Hiern\* the stamens are thirteen or fourteen in number and always connate at the base and surround the hairy rudiment of the ovary. In examining fresh material in the forest the stamens of the male flowers were seen to form a central column, the filaments being completely united at the base. Towards the base seven separate stamens could be distinguished, each of which consisted of a short white curved filament and an anther disposed introrsely ; projecting above this outer ring is a yellowish white stout pedicel 3 mm. in length which terminates in five sessile introrse anthers, the pedicel presumably being composed of the united filaments belonging to the five stamens. The total length of this staminal system is 6 mm., and its members exhibit no great variations except in that one may be epipetalous. I have not been able to determine the same condition in the scanty herbarium material of D. pruriens.

It is obvious that in the staminal whorl of the male flowers there are very many characters which can be used in the study of the ontogeny and phylogeny of the genus *Diospyros*. In descriptions of many species the staminal whorl is not even mentioned, and a somewhat detailed description will therefore be given in this work.

In the regular orientation of a fixed number of stamens, as in D. acuta and D. oppositifolia, and in the paired arrangement of the stamens, as in D. Gardneri, there is a strong resemblance to the Sapotaceæ. Further, the occurrence of a fixed number of stamens and staminodes in the male and female flowers of species which can assume the hermaph-

\* Hiern, *l.c.*, p. 43.



rodite and monœcious condition is suggestive of the genus Sideroxylon and others, where stamens and staminodes are known to occur in the same flower.

In the indefinite groups of stamens a resemblance to Styracæ and many polypetalous orders, particularly with the Anonacæ and Ternstroemiaceæ is suggested.

On the other hand, the central column of united stamens (D. pruriens) and the extensive union of filaments in other species is suggestive of like features in the Malvaceæ and Geraniaceæ, and Hallier asserts,\* though without giving good reasons, that the Ebenales have their origin closely connected with the Malvales, Geraniales, and Theales. That botanist also states† that the genus Scytotetalum, in that it shows numerous stamens inserted on the base of the corolla and on the flat axis of the flower, and in the arrangement of the anther when in bud, possesses characters which bring it near to the Ebenales.

It is important to realize that in the staminal whorl of the male flowers of only twenty species there are types of character which are only met with in natural orders now widely separated.

*The Staminal Whorl of the Female Flowers.*—The members of this whorl in the female flowers are but slightly known. They occur nearly always as an epipetalous series, and only rarely, as in occasional flowers of D. Toposia and others, in the hypogynous position.

The filament is very similar in colour, form, and dimensions to that in the male flower.

The anther is usually hastate in form, and is regarded universally as barren. It consists, as seen in transverse section, of regularly disposed parenchyma with a small strand of vascular tissue in the centre.

The filament is usually glabrous, but the anther in some species, notably D. hirsuta and D. Thwaitesii, is strongly apiculate in consequence of the presence of numerous long

\* Hallier, *l.c.*, p. 85.

† Hallier, *l.c.*, p. 36.

unicellular hairs, as in the anthers of perfect stamens from the male flowers.

In point of number the staminodes are, compared to the stamens of the male, very few. Usually the number is the same as that of the corolla or calyx segments. The series alternate with the corolla lobes when the number of members of both these whorls is the same, as in the four staminodes of D. oppositifolia, D. sylvatica, and D. Embryopteris, and the five staminodes in D. acuta, D. Thwaitesii, and D. hirsuta.

When the staminodes are an exact multiple of the corolla segments they are disposed opposite to and alternate with them, as in the twelve staminodes of D. Melanoxylon, and the eight staminodes of D. Gardneri and D. Ebenum. When the number of the calyx and corolla segments varies the number of staminodes usually shows exactly the same numerical variations, as in D. insignis, D. attenuata, and D. affinis, where the flowers may have their parts in fours and fives, and even threes.

*h. 105.* In D. Toposia there seems to be an erratic number of twelve to sixteen staminodes arranged either epipetalous or hypogynous.

*4-1-87.* *Pistil.*—The pistil is represented in the male flowers of polygamous trees by a central, hairy, apiculate, or flattened disc; in female flowers it is sub-globose or ovoid in shape, green, and glabrous or hairy; in D. Embryopteris and D. pruriens the carpellary wall is covered with a dense layer of multi- and uni-cellular hairs which persist in the fruit; the stigmas are green and sessile; the ovary is four-, eight-, or ten-celled; the ovules are pendulous from the top of each cell of the ovary.

*The relation of the Staminal Whorl in Male and Female Flowers.*—A staminode is similar in form and size to a stamen, and differs from it mainly in that its anther is barren. It may be possible to derive one from the other, and with this object in view I have drawn up a table showing the number and orientation of the members of the staminal whorls for each species.

## Group A.—Species which may be Diccious, Monœcious, and Polygamous.

*Abbreviations* : c.s. = corolla segments ; epi. = epipetalous ; alt. = alternate ; opp. = opposite ; hyp. = hypogynous.

	Stamens of Male Flower.		Staminodes of Female Flower.	
	No.	Arrangement.	No.	Arrangement.
<i>D. hirsuta</i>	...	5 epi. ; alt. with c.s.	...	...
<i>D. Thwaitesii</i>	...	10 or variable ... epi. ; paired and alt. with c.s. as 5 series ; or irregular	5	... epi. ; alt. with c.s.
<i>D. Ebenum</i>	...	16, 20, 32 ... epi. ; connate groups to form series of 8 alt. and opp. to c.s.	5	... do.
			8	... epi. ; alt. and opp. c.s.

*Remarks.*—Exact equality in number and position in one species ; in each of the others the groups of stamens are equal to the separate staminodes in number and position.

## Group B.—Species which are Monœcious only.

	Stamens of Male Flower.		Staminodes of Female Flower.	
	No.	Arrangement.	No.	Arrangement.
<i>D. acuta</i>	...	5, 7, 9 epi. ; separate or paired	...	...
<i>D. oppositifolia</i>	...	8 epi. ; four pairs usually alt. with c.s., but variable ...	5	... epi. ; alt. with c.s.
			4 (rarely 8)	... do.

*Remarks.*—Stamens exact multiple of staminodes, exact equality or slightly variable, not widely different.

## Group C.—Species which may be Dioecious or Polygamous.

	No.	Stamens of Male Flower. Arrangement.	Staminodes of Female Flower. No.	Staminodes of Female Flower. Arrangement.
<i>D. Gardneri</i>	... 12-16	... separate or paired in a series of 8	... 8	... epi.; alt. and opp. with c.s.
<i>D. sylvatica</i>	... 13-22	... epi.; grouped to form series of 8 or 10	... 4	... epi.; alt. and opp. with c.s.
<i>D. Embryopteris</i>	... 24, 30, 40, 64	... epi.; grouped irregularly	... 4	... epi.; alt. with c.s.
<i>D. affinis</i>	... 6-16	... single or grouped	... 6-8	... epi.
<i>D. insignis</i>	... 14-20	... epi.; single or grouped	... 4-5	... do.

*Remarks.*—Irregular. In some the stamens and staminodes are in equal numbered series, or former in multiple series of latter, or there may be an inconstant number and orientation of stamens and even staminodes.

## Group D.—Species which are Dioecious.

	No.	Stamens of Male Flower. Arrangement.	Staminodes of Female Flower. No.	Staminodes of Female Flower. Arrangement.
<i>D. attenuata</i>	... 4-6	... epi.	... 4-5	... epi.; alt. with c.s.
<i>D. Melanoxylon</i>	... 8, 10, 16, 20	... single, or connate to form series of 8...	... 8, 10, or 12	... epi. or hyp.
<i>D. pruriens</i>	... 12-14	... hyp.	... 5	...
<i>D. quiesita</i>	... 16 or x	... hyp.	... 5 or x	... epi.; alt. with c.s.
<i>D. crumenata</i>	... 8-14	... hyp. or epi.	... 8	... epi.; alt. and opp. c.s.
<i>D. Toposia</i>	... 18-33	...	... 12-16	... epi.
<i>D. ovalifolia</i>	... 13-20	... single or grouped	... 4 or (1-7)	...
<i>D. montana</i>	... 16 or x	... single or united to form a series of 8	... 4-12	...
<i>D. oocarpa</i>	... 9-14	... epi. or hyp.	... 3	... epi.
<i>D. Moonii</i>	... 5	...	... 5	...

*Remarks.*—Very irregular; more variable than any of the foregoing groups. In two or three species only is the number of staminodes constant. This group contains half the Ceylon species.

The most perfect agreement in number and position of members of the staminal whorl is in Group A, where the sex relationship is the most complicated, and there is least agreement in Group D, where the sex is dioecious only.

It would appear that the greater the departure from the dioecious condition, the more nearly do the male and female staminal whorls agree; the dioecious condition is further from the hermaphrodite state than any of the Groups A, B, and C.

From the above table we can deduce certain generalizations which will probably throw some light on the exact ontogenetic relationships of the organs considered. The remarks on this subject are made purely in relation to the flowers of the Ceylon species examined, and it is possible that examination of other species in other countries may lead to quite contrary or to similar conclusions.

Since we have classified certain species into groups according to their sex relationships, it will be convenient to adhere to the above plan in describing the staminal whorl in each sex group.

We will commence with Group A, in which there are species having the monœcious, dioecious, and polygamous condition. The complicated sex relationships here existing show that it is possible to have on the same tree every stage between a perfect hermaphrodite flower and a staminate or pistillate flower. The hermaphrodite flower in giving rise to a staminate or pistillate flower must undergo abortion of the gynoecium and anthers respectively. In every pistillate flower an epipetalous ring of staminodes exists, and in every staminate flower a rudimentary pistil remains. Can it be that the unisexual flowers have been derived from the hermaphrodite, or *vice versa*? In one species of this group, viz., D. hirsuta, we see that in number, form, and orientation the stamens of each male flower exactly agree with the staminodes of the female flower. Such equality in the staminal whorl does not occur in any other Ceylon species of Diospyros. The complex sexual relationships may have

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been derived from a hermaphrodite type by sterilization without reduction in number of parts.

If the unisexual type was the primitive, the flowers are now perhaps progressing towards the production of an uniform hermaphrodite type. When one considers how definitely monœcious or dicœcious many other species are, and that sterilization of sporogenous tissue is frequently met with in the ontogeny and phylogeny of the higher plants, it seems more reasonable to regard the more specialized condition of unisexuality as the latest phase in development, and, in view of other facts, to believe that the hermaphrodite condition is the more primitive in this genus. The female inflorescences in many species appear to have undergone much abortion; this is probably true of the parts of the flower also. It is not meant to imply that the species showing this condition are necessarily members of the most primitive section of *Diospyros*. The statement is made purely in relation to the evolution of sex in *Diospyros*, a development which may or may not be correlated with that of the vegetative organs.

It would therefore seem an easy task to derive the present mixed sexual condition in *D. hirsuta* from a primitive hermaphrodite flower. In the production of female from hermaphrodite flowers the anthers, though persisting, become barren. It seems more reasonable to regard a staminode as being a stage in the abortion of a stamen, rather than one in the development of a stamen towards fertility.

If, however, we consider another species showing the same variation in sex, viz., *D. Thwaitesii*, the evolution from the hermaphrodite flower is more complicated. In this species the staminodes are, as in the female flowers of *D. hirsuta*, five in number and arranged on the corolla so as to alternate with their lobes. In the male flowers, however, the number of stamens always exceeds that of the staminodes of the female flower, there being usually ten, and in one case twelve fertile stamens present. It is interesting to note that when there are ten stamens present these are arranged

in pairs, each pair alternating with the corolla segments and being attached to the corolla as one or two filaments.

When there are less than ten stamens some are arranged in pairs and others singly, but always as a series of five alternating with the corolla lobes. It would thus appear that if we have to maintain the importance of abortion we must have the primitive hermaphrodite flower with numerous stamens arranged in pairs or otherwise. It would by no means necessitate a complex series of changes to derive the five-seried staminal whorl of the female flower from that of the male, the barrenness in the anthers of the staminodes being followed by a reduction of each pair to a single member; the inner stamen is always small.

Now, let us take the case of D. Ebenum, the flowers of which may be polygamous, dioecious, or monœcious. We have seen that though the male inflorescence and female flowers usually occur on separate trees, examples have been found where a true female flower replaced a member of a male inflorescence. The staminal whorl of the female flowers is constant in number, form, and orientation. There are always eight epipetalous staminodes alternating with and opposite to the corolla segments. In the male flowers a variable number of stamens occur, but coalescence of the filament occurs so frequently that the resultant number of groups is relatively small. In one case there were sixteen stamens, either single or in groups of two and three, while in another flower thirty-two stamens occurred showing various degrees of coalescence, but in each of these the resultant groups were eight in number and arranged so as to alternate with the corolla segments. Hiern\* mentions the occurrence of as many as thirty-two stamens on eight filaments. A. B. G.

This being the case, we have another example in which the origin of unisexuality can be easily understood, since the staminal whorl always forms a series of eight. The monœcious state would represent the intermediate between a page 95.

\* Hiern, *l.c.*, p. 208.

hermaphrodite and dioecious condition. It is important to realize that here we have a species which is mainly dioecious, but where the staminal whorls of male and female flowers agree in number, if we regard a group in the male as equivalent to one member in the female.

In the species belonging to this group the production of a pistillate flower is attained by sterilization of the male sporogenous tissue (the anther still persisting) followed by a reduction of pairs or groups to single members. The original hermaphrodite flower still occurs on polygamous trees and always possesses stamens of different sizes, the innermost being the smallest.

The accessory whorls of the male and female flowers of this and in fact of all the other species are widely different, but since the differences are those of size and form they may be neglected in considering the evolution of unisexuality in Diospyros.

If we now consider the species in Group B, D. acuta and D. oppositifolia, which are only known in the monœcious condition, we find that they can be easily arranged in a series to show the similarity in the whorls of male and female flowers. In D. oppositifolia the female flowers usually possess four epipetalous staminodes alternating with the corolla segments. In one female flower there were eight separate staminodes arranged so as to be alternate with and opposite to the corolla segments, each being typical in form and possessing a completely barren anther. In the male flowers of this species there are always eight epipetalous stamens usually paired, with the inner member the shorter of the two, but each stamen is attached to the corolla by its own filaments. The pairs invariably alternate with the corolla segments, though this orientation is liable to variation. The variation in the male staminal whorl is where the members of one or more pairs are not exactly opposite one another, a deviation from the normal which tends to simulate the occasional eight separate staminodes of the female flower. It is therefore very easy to correlate the staminal whorl of the male and female flowers of D. oppositifolia with



one another and consequently to derive both from a common sex type.

In D. acuta the staminal whorl of the female flowers consists of five epipetalous members alternating with the corolla segments. The male flowers have, according to Hiern,\* from four to five stamens, corresponding to the number of accessory whorl segments, and presumably alternating with those of the corolla. It would thus be quite as easy to derive each sex from a common hermaphrodite flower as with D. oppositifolia. h. 96

The male flowers of D. acuta, though usually possessing five epipetalous stamens alternating with the corolla segments, often have seven to nine epipetalous stamens, single or united in pairs and of very unequal length. If the sexes in this species have originated from a common hermaphrodite flower then the original type may have possessed numerous stamens, which in the evolution of the female flower have undergone abortion at a quicker rate than in the male. The very small stamens which occur when the total number is more than five per male flower are perhaps in their last stages, and may represent a phase passed through in the ontogeny of the female staminal whorl from the hermaphrodite type. h. 90.

We have therefore seen that in considering flowers of species which are (a) diœcious, monœcious, and polygamous, and (b) monœcious only, the staminal whorls of the male and female flowers are at the present time in general agreement in number, form, and orientation, and the sexes in these species can be derived from a hermaphrodite type of flower having a relatively large number of stamens. In the remaining groups, which are either diœcious only or diœcious and polygamous, the relationships are more complicated.

If we take the Group C, which shows the diœcious and polygamous condition, we find a great variation in the staminal whorl of the different species. The simplest arrangement is perhaps in D. Gardneri. Each female flower

\* Hiern, *l.c.*, p. 183.

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of this species possesses eight epipetalous staminodes arranged opposite to and alternate with the corolla segments. In the male flowers the number of stamens is large, there being from twelve to sixteen in each flower. When sixteen in number they are usually as eight pairs, the members of each pair being united at the base of the filaments and having the inner stamen smaller than the outer. When only twelve stamens occur these are often arranged as four pairs and four single.

In each case, whether there are sixteen or twelve, they always form an epipetalous series of eight, each pair being either opposite to or alternate with the corolla segments. The inner stamens are always small, and by their abortion a series of eight would result. This condition, which prevails in many flowers, may represent the transition of the staminal whorl of the female flowers, in which case it would be easy to derive both sexes from a common hermaphrodite flower having a large number of stamens. Such a hermaphrodite flower does exist at the present time in those trees showing the polygamous condition. In the hermaphrodite flowers there may be as many as sixteen perfect stamens arranged as a monadelphous hypogynous ring, or arranged part epipetalous at the base of the corolla and part hypogynous. The parts of the pistil and also the seeds of polygamous flowers resemble those of true female flowers. If we assume that the primitive type of flower was hermaphrodite, then a very definite abortion in either of two directions must have taken place, some of the trees having, so to speak, allowed the pistil of every flower to entirely abort, while others reduced the number of stamens in each male flower and eventually suffered sterilization of the male sporogenous tissue. Other trees have undergone occasional sterilization of the pistil, resulting in the polygamous state so prevalent at the present time.

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The next most simple case in this group is seen in D. sylvatica. In this species the female flower possesses four epipetalous staminodes disposed so as to alternate with the

corolla segments. The male flowers possess a very large number of stamens, there being rarely less than sixteen and very often over twenty-two in each flower. The stamens are nearly all in pairs, each having the inner stamen shorter than the outer and with the filaments of each pair united throughout the greater part of their length; sometimes three anthers are supported on the same united filament.

In some flowers I have found eight pairs arranged opposite to and alternate with the corolla segments, but in by far the greater number of flowers the pairs of anthers are in excess of twice the corolla segments. In one flower possessing ten pairs of stamens there was always a pair alternating with the corolla segments; the remaining six pairs were arranged as two pairs on each of two corolla segments and a separate pair on each of the other two corolla segments.

If we allow that in the production of the female flower sterilization and reduction in number has occurred, we can easily understand the derivation of the four-seried flower from one having staminal members alternate with and opposite to each corolla segment, as is now seen in male flowers possessing eight groups of stamens. Hence the evolution from the hermaphrodite type is rendered possible.

In D. Embryopteris we have a difficult case, since there is practically nothing to connect the four staminodes of each female whorl with the male ring of thirty or forty stamens. h-pf. The indefinite stamens in each male flower are sometimes separate, at other times united in pairs, and may be epipetalous or hypogynous. In D. affinis the conditions are almost the same as in D. Embryopteris, since the male staminal whorl consists of sixteen or more members apparently cf. h-pf. disposed without any definite relation to the accessory whorls. The stamens occur in pairs or are single, and form an epipetalous ring or hypogynous group. Each female flower possesses from six to eight staminodes arranged on the corolla opposite to and alternate with its segments.

Hiern\* gives the number of stamens in each male flower of D. affinis as six to sixteen, usually about nine, and some or all in pairs. It is thus clear that in D. Embryopteris and D. affinis the staminal whorls are widely different, and until some intermediate links have been observed the evolution of the sex must remain particularly problematical.

Turning to Group D. (dicecious only), in D. attenuata the members of the staminal whorl are few in number. Each female flower possesses four to five epipetalous staminodes which alternate with the corolla segments; whereas each male flower has a variable number, four to six, of epipetalous stamens, but their orientation is not constant. It is somewhat remarkable if no fixed orientation exists when the members of the male staminal whorl are so few in number. The male flowers are so very small, often less than 1 mm. diameter, that to determine the exact orientation is a difficult undertaking.

The flowers of D. Melanoxydon show a variability in the staminal whorl in both sexes. The female flower possesses accessory whorls in parts of five and six. In those I have examined there has usually been twelve staminodes, either hypogynous or epipetalous, but in positions opposite to and alternate with the corolla lobes. Hiern† states that the staminodes may be eight or ten in number. Each male flower possesses from eight to twelve and even sixteen stamens. When sixteen in number they are always in eight pairs, though according to Hiern‡ it is rare that one finds eight single stamens only. In one flower there were twenty stamens arranged as a hypogynous group. The variability in number of stamens and staminodes and their occurrence mainly in the hypogynous position renders it inadvisable to make any definite statement as to the derivation of one from another or from a common parent.

In the flowers of D. pruriens and D. quæsitæ the staminodes of each female flower are equal in number to and alternate with the corolla segments, whereas the male flowers possess a more or less hypogynous group of twelve or twenty

\* Hiern, *l.c.*, p. 169.    † Hiern, *l.c.*, p. 169.    ‡ Hiern, *l.c.*, p. 160.

stamens. In D. crumenata the staminodes of each female flower are in number an exact multiple of the corolla segments and are disposed opposite to and alternating with them, whereas the male flower resembles D. quæsita and D. pruriens in the indefinite hypogynous character of the stamens.

There is one species—D. Toposia—in this group which shows an unstable staminal whorl in the female flowers, the number usually being greatly in excess of the members of other whorls, and presents no fixed orientation to them. Each female flower of D. Toposia may possess from twelve to sixteen staminodes, which form an epipetalous or partly hypogynous ring; the stamens of each male flower may be from ten to over thirty in number, of unequal length, forming a hypogynous group terminating the receptacle. 1294  
9.1.96

#### VII.—AFFINITY. 11.10.5, 106.

The phylogeny of the Ebenales has formed the subject of much discussion.

Hiern (p. 62) states that the Ebenaceæ shows the closest affinity to the Olacineæ, Styraceæ, Anonaceæ, Ternstroemiaceæ, Sapotaceæ, and Illicineæ, but also draws attention to the points of difference between these natural orders and the Ebenaceæ. He also states (p. 63) that other orders including Tiliaceæ, Magnoliaceæ, and the Euphorbiaceæ show affinity in a less degree to the Ebenaceæ.

Miers compares them with the Anonaceæ and suggests their grouping among the polypetalous section; Choisy points out their proximity to the Ternstroemiaceæ.

Parmentier, in his monograph on the histology and morphology of the Ebenaceæ, does not commit himself to statements as to the phylogeny of the natural order.

Hallier, on the other hand, points out that there are many features in which the Ebenales resemble many other natural orders, and in this respect goes into much more detail than Hiern.

Under the circumstances I cannot do better than point out the main facts as supplemented in the present paper, and

leave the question of affinity until detailed information for the remaining species is at hand.

The fossil species described by Unger, Ettingshausen, Massalongo, and others, the present distribution through tropical regions of the eastern and western hemispheres, in sub-tropical South Africa and Madagascar, and the occurrence in temperate regions are suggestive of great age. The fossil forms, the conspicuous differences between existing species, especially between those in Ceylon, together with the probable early extinction by natural causes of many Ceylon species, suggests the likelihood that the Ebenaceæ had in the past a much wider distribution and a larger number of species than at the present day.

The great point of interest in connection with the Ceylon species is the fact that a good artificial key for working out the species can be constructed on separate characters, *e.g.*, the leaf, flower, or seedlings. The differences in leaf characters are very marked. It is impossible to confuse the tough large leaf of D. Moonii or D. acuta with the thin leaves of D. Thwaitesii and D. montana, or with the thin hairy leaves of D. pruriens. The pellucid character of the veins in leaves of D. Ebenum, D. Embryopteris, D. Toposia, and D. Gardneri separates these species from one another and from all other species, and questions of size and form provide sufficient differences for separating the remaining species. Then again we have seen that it is very convenient to group the species according to their sex characters.\*

A good artificial key for the Ceylon representatives can be made on the characters of the seedlings alone, the classification being based on the number of traces per cotyledon, abortion or persistence of the median cotyledonary traces, characters of cotyledons, epicotyledonary leaves, and hypocotyl.

The secondary xylem is the most constant structure throughout the genus, and in the respective species shows differences only in percentage number of the elements.

\* Sex in Diospyros, Brit. Assoc., Belfast, 1902. p. 819 (1903).

[To be continued in next number.]

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W.D. Hiern.  
22 Dec. 1904.

THE GENUS DIOSPYROS IN CEYLON :  
ITS MORPHOLOGY, ANATOMY,  
AND TAXONOMY.

*Part ii.*

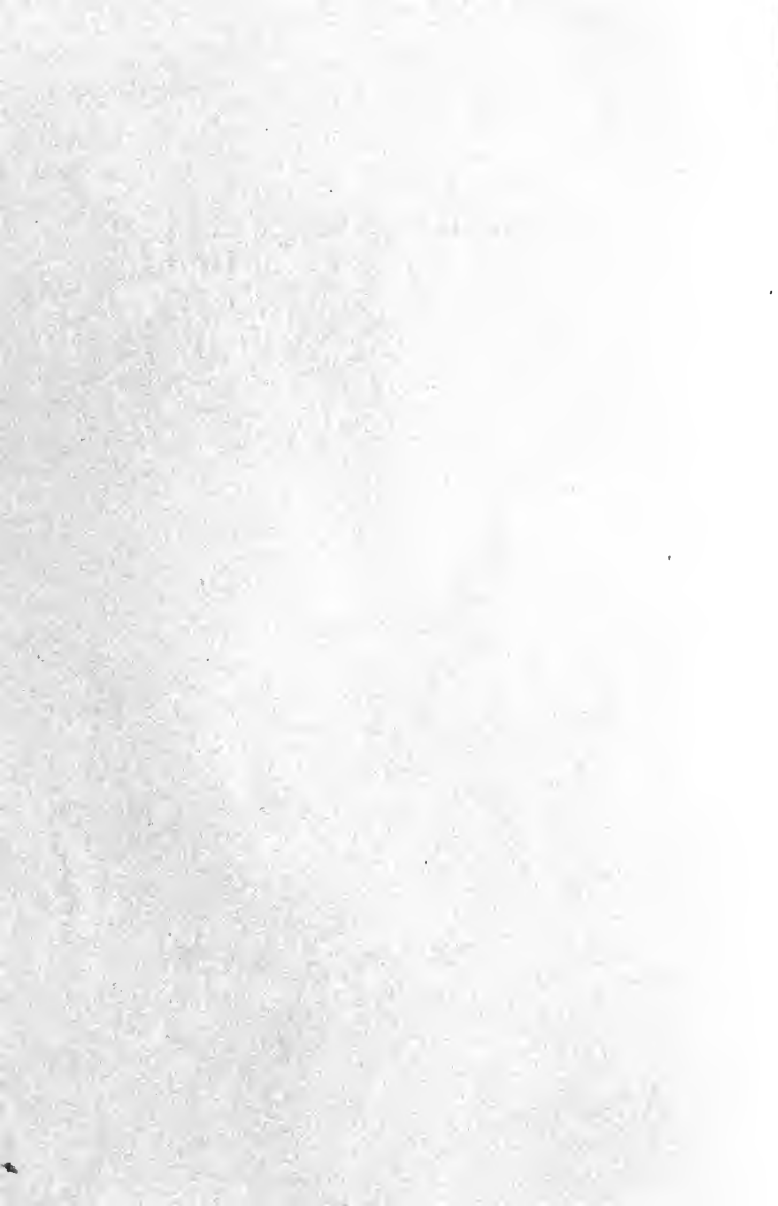
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BY HERBERT WRIGHT.

(With Plates I.-XX.)

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[Reprinted from "*Annals of the Royal Botanic Gardens*," Vol. II., Part II.]



# The Genus *Diospyros* in Ceylon: its Morphology, Anatomy, and Taxonomy.

BY

HERBERT WRIGHT.

(With Plates I.-XX.)

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## Part II.

THE present contribution is the concluding portion of my paper, the first part of which was published in January, 1904. For local convenience the species are described in the same order as previously adopted in Trimen's *Flora of Ceylon*. A reference to Hiern's monograph for each species is also quoted. The synonyms for each species are not given since reference can always be made to those quoted in Hiern's comprehensive monograph on the *Ebenaceæ*.

In Part I. I explained that the flower systems were previously imperfectly known, and the descriptions given by Trimen and Hiern are frequently inadequate on account of the limited supply of fresh material which those botanists had at their command. In Trimen's *Flora* the staminal whorls of the male and female flowers, and often the accessory whorls, are not separately described.

In many species the flowers or fruits are not described in Trimen's *Flora*, but in several of these cases descriptions are obtainable from Hiern.

The male and female flowers, timbers, fruits, seeds, and seedlings have now been obtained for every Ceylon species except *D. Moonii*, and many of them are described here for the first time from material obtained in this Island.

The object has been to work out all details of our recognized species rather than to subdivide into varieties. Hence the question of the possibility of two species in *D. montana*, *Roxb.*, *D. Embryopteris*, *Pers.*, and *D. Ebum*, *Koen.*, is only briefly dealt with. I am, however, unable to agree with the grouping of *D. Thwaitesii*, *Bedd.*, *D. Moonii*, *Thw.*, and *D. hirsuta*, *L.*, under one species—*D. hirsuta*, *Linn.*, as adopted in Hiern's monograph, and have, therefore, for reasons obvious in the descriptions of these species, adopted the separate classification used by Trimen.\*

**1. *D. ovalifolia*, R. Wight, Ic. t. 1,227 (1850).**

Kunumella, Habara, S. ; Vedukkanari, T.

Thw. Enum. 181 (1864). C. P. 1825 (2,533). Fl. B. Ind. III., 557. Wight, Ic. t. 1,227 (1850). Hiern, Mon. Eben. 237.

A moderate-sized tree, dicæcious ; bark with brown and pale alternating streaks ; becomes partly deciduous in the dry season in the Northern Province ; flowers in September and fruits in March. Leaves 35–130 mm. long, 6–50 mm. wide, alternate, accrescent and crowded, oval or lanceolate-oblong, obtuse or rounded at apex, narrowed at base, glabrous, thinly coriaceous, paler beneath with prominent venation ; petiole 3–7 mm. long.

*Male inflorescence* consists of sessile clusters of 3–7 flowers mainly on woody twigs ; bracts form a basal involucre. (See pl. XV., fig. 1.)

*Flowers* yellow, 5–10 mm. long ; they appear from September to December.

*Calyx* green, slightly hairy, and openly campanulate ; segments 4–5, apex rounded.

*Corolla* yellow, urceolate, glabrous or nearly so, 5–8 mm. long ; segments 4–5, obtuse apex, recurved when mature.

*Stamens* 13–20, paired, surrounding central rudimentary disc ; *filaments* unequal, about one-sixth the length of *anthers* ; *anthers* brown and glabrous.

\* I have, since writing the above, received a communication from W. P. Hiern, Esq., in which that gentleman agrees with the separate classification here adopted.

*Pistil* rudimentary, apiculate, hairy.

*Female flowers* solitary or as sessile clusters of 3-9 flowers in axils of leaves or on woody twigs; buds pubescent, globular, surrounded by two or three small deciduous bracts. (See pl. XV., fig. 2.)

*Calyx* segments 4-5, brown or green, pubescent, 3 mm. long, rounded or bluntly acute at apex.

*Corolla* yellow, conical in bud, segments 4-5, shorter than tube.

*Staminodes* 1-7, usually 4, sometimes absent, hypogynous or at base of corolla.

*Pistil* green, pubescent; stigmas 2-4, green, reniform; ovary pubescent, conical, 4-celled (see pl. XV., figs. 4 and 5)

*Fruit* globose, 2 cm. diameter, solitary, subsessile, 1-3-4,—usually 1-seeded, glabrous; fruiting calyx enlarged, thickened, reflexed. Fruits ripe in March.

*Seeds* hard, globose when solitary, wedge-shaped when numerous; testa brown and superficially striated, 7 mm. diameter, 9 mm. long; endosperm abundant, equable; embryo white, 5 mm. long. (See pl. XV., fig. 3.)

*Seedlings* epigeal; cotyledons detached early, testa does not split (*cf.* *D. pruriens*); *cotyledons* ovate, rounded base and apex, 4-6 mm. long; *hypocotyl* white or yellow, thin, 50-60 mm. long, 2 mm. diameter; *epicotyledonary* stem 8 mm. long; first epicotyledonary leaves form an opposite pair, ovate, hairy, 8 mm. long, 4 mm. wide; *traces* 2 per cotyledon which are not split to any great extent at the node and give a four-cornered appearance to the vascular cylinder in the hypocotyl, thus resembling *D. montana* and *D. Ebenum*; epicotyledonary traces one per leaf, conspicuous in the ungerminated embryo, particularly the phloem. In the apex of the primary root there are only eight strands, which may be the result of the splitting of four cotyledonary or may consist of two epicotyledonary and six cotyledonary strands.

*Timber* brown or dirty white or faint red in colour, inferior, sapwood and heartwood of very old trees possessing

a high per cent. of tracheal elements and small quantity of gum-resin. The heartwood is usually small and considerably decayed. The contents of the elements are scarce compared with the red or black woods of other species. Many specimens show thinly streaked heartwood, the black lines of which help to form a pretty pattern (*cf.* *D. quæsitæ*). (See pl. I., fig. 6.)

*Uses*.—Only the timber is used.

*Distribution*.—Common in dry region and intermediate zone, rare in moist region. Trincomalee, Anuradhapura, Kalugalla, Vavuniya, Madawachchi. Also in Madras and Anamalai hills.

2. ***D. montana***, *Roxb.*, Cor. Pl., p. 37, t. 48 (1795).

Mulkarunkali, Katukanni, Vakkana, T.

Thw. Enum. 423. C. P. 1,909 (3,774). Hiern, Mon. Eben. 220. Fl. B. Ind. III., 555. Wight, Ic. t. 1, 125.

A moderate-sized or small tree, dioecious, partially deciduous in the Northern Province; bark yellowish or silvery grey, smooth, shiny, thin, being 4–6 mm. in thickness, yellow when freshly cut; sharp spines on main stem, branches, and twigs, stumps of spines often characteristic of old trunk; flowers in September; fruits ripe in March–September; tree flowers when only 75 mm. diameter. Leaves 25–100 mm. long, 15–50 mm. wide, alternate, oval, oblong or lanceolate-oblong, obtuse or rounded apex, rounded or cordate at base, finely pubescent when young, glabrous when old, thin, yellowish-green, venation not pronounced; *petiole* 2–12 mm. long, finely pubescent. (See pl. XVI., fig. 7.)

The spiny character of the stem structures is said to be found only on one variety of this species, but it has been noticed on every plant reared at Peradeniya, even when only two years old.

*Male inflorescence*; Cymes 3-flowered or paniced in axils of small caducous bracts or young persistent foliage leaves. Main peduncle of inflorescence thin, green, 2–6 mm. long. Each lateral flower arises in the axil of a small narrow

bract 2 mm. in length, and is supported on a thin pedicel 2-5 mm. long. Primary and secondary pedicels show great variation in length. Flower-bud 4 mm. long, conical, apical, scentless; mature flower 8 mm. long and somewhat bell-shaped when segments recurved. (See pl. XVI., fig. 9.)

*Calyx* segments 4, rounded or deltoid, thin, pubescent, small.

*Corolla*, wide throated, segments 4, twisted at apex, urceolate, white or yellow.

*Stamens* numerous or 16, in equal or unequal pairs, often united to form 8 pairs; *anthers* brown, glabrous, apiculate, 2-4 mm. long; *filaments* white, glabrous, absent or 1 mm. long.

*Ovary* is a flattened rudimentary disc often of considerable size, which may yet be observed to develop into a ripe fruit; the polygamous condition will probably be found if a sufficient number of trees are examined.

*The female flowers* are usually solitary on woody twig or in axil of leaf (see pl. XVI., fig. 10); peduncle 4-12 mm. long, glabrous or pubescent; bracts small, caducous.

*Calyx* green, hairy, 10 mm. diameter; segments 4, 2-5 mm. long, rounded apex.

*Corolla* white or yellow, wide-throated, 11 mm. long, glabrous; segments 4, rotate.

*Staminodes* small, 4-12, usually 4.

*Pistil* green, glabrous or nearly so; styles 4, bifid at apex, glabrous; ovary glabrous, 8-celled.

*Fruit* globose-apiculate, 12-20 mm. diameter, 16 mm. high, glabrous and shiny, cherry-red to brown in colour; fruiting calyx thin, glabrous, accrescent or nearly horizontal, slightly enlarged, with segments 6-8 mm. long. (See pl. XVI., fig. 7.)

*Seeds* 2-6-8 per fruit, semilunar, wedge-shaped, brown, smooth, 8 mm. long, 4-5 mm. wide, 3 mm. thick; endosperm equable, copious; embryo white, small, 8-10 mm. long. (See pl. XVI., fig. 8.)

*Seedlings* epigeal; *cotyledons* persistent, ovate, tapering towards apex, green, glabrous, 30 x 15 mm.; petiole of

cotyledon flat,  $2 \times 2$  mm.; *hypocotyl* green, cylindrical, faintly pubescent, 60 mm. long, 2 mm. diameter. The *epicotyledonary* system shows delayed development; leaves alternate, the first leaf occurs 3-8 mm. above the cotyledonary node, at right angles to the plane of the cotyledons, 30 mm. long  $\times$  9 mm. wide, green; the subsequent leaves arise in a spiral, and in size and form are similar to the first (*cf.* *D. Ebenum* and *D. Gardneri* for development).

Two *traces* per cotyledon; one trace to each epicotyledonary leaf; feeble splitting of cotyledonary xylem, epicotyledonary traces die out in hypocotyl.

*Timber*.—When freshly cut the wood is of a dirty white colour, but on exposure assumes a reddish tint. Black heartwood usually small, central part generally rotten. Some specimens show large heartwood not jet black, but often streaked (*cf.* *D. affinis* and *D. oocarpa*), and when such samples are sound the timber is equal to calamander in beauty. One specimen 30 cm. diameter, possessed a large heartwood consisting of a small black centre and a peripheral portion beautifully variegated in tints of brown and black. Most samples are inferior to ordinary ebony; the timber possesses a high per cent. number of parenchymatous and tracheal elements. (See pl. V., fig. 19.)

*Uses*.—Only the timber is used.

*Distribution*.—Common in dry zones, especially along the roadsides to Trincomalee and Mannar; characteristic of poor low-lying xerophytic forests. Jaffna, Matale, Trincomalee, Vavuniya, Puttalam, Mannar, Anuradhapura, Habarana, Kanthalai, Madawachchi. Also in India, Malaya, Burma, and Tropical Australia.

3. **Diospyros Embryopteris**, *Pers.*, Syn. 11, p 624, n. 6 (1807).

Timbiri, S.; Panichechai, T.

Thw. Enum. 178. C.P. 1,915. Fl. B. Ind. III, 556. Wight, Ic. t. 843, 844. Bedd. Fl. Sylv. t. 69. Benth. and Trim. Med. Pl. t. 168. Hiern, Mon. Eben. 257.



A large tree, evergreen, dioecious, and polygamous ; trunk fluted when old, black, thick, and scaly, red when freshly cut; branches spreading, forming dense wide head, which in young trees is often conical in outline ; flowers March-July; ripe fruit, September-February.

*Leaves* 120-200 mm. long, 25-55 mm. wide, alternate, oblong or lanceolate-oblong, acute-lanceolate, acuminate or obtuse at apex, rounded or narrowed at base, glabrous except slight puberulence on petiole, thick and coriaceous, pale green colour, pellucid venation, veins prominent in dried leaves ; *petiole* thick, rigid, slightly pubescent, 5-13 mm. long.

The flowers of some male trees often show a central pistil possessing definite loculi, and which often assumes a very large size. Mature seeds from a polygamous tree have not yet been obtained.

*Male inflorescence* arises as a globular apiculate axillary structure, strongly pubescent, supported on short stout peduncles and surrounded by regularly arranged bracts, 3-7 flowers (see pl. IX., figs. 1-5) ; peduncle yellowish-white to green, 20 mm. long, 2 mm. diameter, covered with fine coating of silvery unicellular hairs ; pedicel of each lateral flower 4 mm. long ; bracts large, one to each flower, greenish-white, frilled or straight margin, broad base, acuminate apex, both sides pubescent, early deciduous, length 8-10 mm. ; bracteoles small, two on each pedicel arranged one on each side as an opposite pair at right angles to antero-posterior axis ; brownish-black, caducous, acuminate apex, 2 mm. long ; scar inconspicuous. *Flowers* 6 mm. long and ovoid in bud, when open 10-15 mm. long.

*Calyx* segments 4-5, accrescent, rounded or acuminate apex, 3-5 mm. long, greenish, covered with silky unicellular hairs on both sides, cup-shaped in mature flower.

*Corolla* segments 4-5, canary-yellow in colour, ovoid, 3 mm. long, rounded apices, imbricated sinistrorsely in bud, segments in open flower are erect or strongly curved outwards and downwards ; total length of corolla 8-13 mm., diameter

of open flower 10 mm.; corolla throat is wide and covered with silky unicellular hairs on both surfaces.

*Stamens* 24-30-40-64 (very unequal numbers), form epipetalous ring around abortive pistil or occupy central position; very unequal in length, often united throughout greater part of filament; usually in pairs, average length 8 mm.; *anthers* free, equal in length, reddish-brown rectangular outline when mature, glabrous, attenuate apex; *filaments* united, white, short, and covered on all surfaces with long unicellular hairs; *pollen* grains circular, even outline, brownish-yellow, finely granular contents.

*Pistil* usually occurs as a flattened circular central apiculate disc, or as a bunch of hairs positioned on the receptacle; in several cases the pistil assumes large dimensions with ovary many-celled.

*Female inflorescence* arises as globular structure in axil of normal foliage leaf, 1-5 flowers, subsessile or cymose; peduncle 10 mm. long, 4 mm. diameter, covered with yellowish-white hairs which rapidly turn to brownish-red; bracts usually 4, 10 mm. long, brown, bluntly acuminate apex covered with unicellular hairs; lower two form an opposite pair at right angles to antero-posterior axis, upper two are larger, and arranged one on each side at right angles to the first pair, but at different levels.

*Flowers* occur one in the axil of each bract, but the upper pair usually drop; very frequently the lower pair do the same, thus reducing the inflorescence to a peduncle showing four leaf scars along its length and terminated by the oldest and fruiting flower (*cf.* *D. Gardneri*). (See pl. IX., figs. 7-11.)

*Flowers* larger than in male and largest in Ceylon *Diospyros* group, measuring 20 mm. high, 30 mm. diameter when mature.

*Calyx* 3-4-5-lobed, accrescent in young flower, but becomes horizontal shortly after fertilization, and finally the margins are recurved; segments ovate, tapering towards apex,

15 mm. long, 15 mm. wide at base, glabrescent or covered with long black unicellular hairs.

*Corolla* wide-throated, 3-4-5-lobed, yellow; segments broad, 18 mm. long, 10 mm. wide, apices recurved, apex rounded or sub-acute.

*Staminodes* 4, alternating with corolla segments, adnate to corolla tube, short, hairy; sometimes 1-12 in number, and may possess fertile anthers. (See pl. IX., fig. 12.)

*Pistil* globular-apiculate in bud, yellowish-green, and covered with multicellular glands borne on many-celled pedicels, forming a dense layer 1 mm. thick in bud; styles 4, hairy; stigmas lobed and undulated; ovary 8-celled, loculi in four pairs alternating with calyx segments, sometimes 6-celled in pentamerous and trimerous flowers; fruiting calyx deeply 4-lobed, enlarged, strongly reflexed margin, woody, hairy or glabrous; fruit usually solitary, subsessile or pedunculate, globular or ovoid, very large, 45 mm. high. The remnants of the multicellular glands, many of which are dead and changed to a brown or red colour, give the fruit a "rusty mealy" appearance; carpellary wall pulpy and rich in gum and tannin (*cf.* *D. crumenata*; *D. quæsitæ*). (See pl. IX., fig. 6.)

*Seeds* 4-8 per fruit, large, 15 mm. wide, 8 mm. thick, 25 mm. long; brown testa, elliptical-wedge shape; endosperm copious, white, equable; embryo white, large. (See pl. XVIII., fig. 7.)

*Seedlings* epigeal, *cotyledons* detached early in embryo and measure 16 × 9 mm., pale yellow, never green or assimilatory; hypocotyl 30-40 mm. long, yellow to green turning black; *epicotyledonary* system shows enhanced development; epicotyledonary stem 35-40 mm. long, 2 mm. diameter, red, pubescent; first epicotyledonary leaves form a subopposite or opposite pair and persist alone for some time and carry on the assimilatory work allotted to cotyledons; *traces* 3 per cotyledon, considerably split, continued into root.

*Timber* usually white with occasional black strands; sapwood always white when freshly felled, but on exposure turns faintly brown; black heartwood is very small even in

centre of very old trees ; black strands occur irregularly in parts of the sapwood usually in association with wounds. This species attains a very large size in the wet and dry zones. The coloured contents of the elements are rarely abundant and the tree is therefore seldom felled with a view to obtaining ebony therefrom. Seasonal rings of growth are poor and irregular, but visible to the naked eye (see pl. V., fig. 20). Some specimens possess 85.1 per cent. of fibres ; nevertheless the timber is very inferior to ebony, and is even less durable than red woods of other species.

*Varieties.*—Var. *atrata*, Thw. l.c. C. P. 2,731.

Leaves thinly coriaceous ; buds, peduncles, and calyx densely covered with brown hairs.

Var. *nervosa*, Thw. l.c. C. P. 1,910.

Leaves very coriaceous, veins prominent on both sides, rounded at base ; buds, peduncles, and calyx covered with black hairs ; calyx segments enlarged, erect, and about as long as fruit.

*Uses.*—The fruit possesses a large quantity of gum and tannin, and the juice is used as a tan for fishing nets and for the planks of boats. The fruit and the bark both possess astringent properties and are used medicinally. The leaves are sometimes eaten as a vegetable. The timber is occasionally used for masts and yards for small boats.

*Distribution.*—Common in dry countries, especially along banks of streams, tanks, &c., invariably associated with *Terminalia glabra* in these localities ; also occurs in the moist regions, particularly along streams, and associated with *D. Moonii*, Thw. Galle, Rayigam korale, Ratnapura, Ambalawa, Bibile, Viriniya, Bintenna, Hinidum, Vavuniya, Jaffna, Madawachchi, Hantane, Gangaruwa, Kadugannawa. Also in India and Malaya.

4. **Diospyros Toposia**, Hamilt. in Trans. Linn. Soc., Vol. XV., p. 115 (1827).

Kahakala, Kaluwella, S. ; Vellei Thoverii, T.

Thw. Enum. 179. C. P. 1,911. Fl. B. Ind. III., 556.  
 Hiern, Mon. Eben. 263.

A large or moderate-sized tree, dioecious, evergreen; branches glabrous, forming dense round head (*cf.* D. Embryopteris); bark thick, black, or dark grayish-brown. *Leaves* alternate, 75–300 mm. long, 25–80 mm. wide, acuminate apex, narrowed or rounded at base, glabrous, coriaceous, venation close, pellucid (*cf.* D. Ebenum), prominent when dry; midrib depressed on upper surface, green, paler on under surface; *petiole* stout, grooved, 5–12 mm. long, glabrous.

Flowers January–April–November; fruits ripe August–December.

*Male inflorescence* arises in axil of new or old normal foliage leaf or caducous bract. In the simplest case the cyme is 3-flowered, each lateral flower arising in the axil of a bract. The pedicel of each lateral flower bears a small bracteole (at an angle of 90° from the bract at the base of pedicel), which appears late and is positioned immediately beneath the calyx; bracts at base of peduncle green, pubescent, long tapering apex, prominent midrib, 7 mm. long and 2 mm. wide; bract at base of pedicel of each lateral flower is hood-shaped, has shortly tapering and acute apex, ventral surface pubescent, 2 mm. long and 2 mm. wide; bracteole on pedicel of each lateral flower is hood-shaped, ventral surface covered with short brown hairs, 1.5 mm. long, 1 mm. wide; primary peduncle green, covered with caducous or persistent brown hairs, 8–12 mm. long; lateral pedicels green, hairy, about 5 mm. long, and extending higher than median flower. (See pl. X., figs. 7 and 8.)

In a more complex inflorescence the lateral flowers arising on the long peduncle repeat the dichotomous structure detailed above; in cultivated specimens inflorescence 3–12-flowered.

*Flowers* yellow, globose-ovoid in bud, and measuring 8 mm. long, 5 mm. diameter; open flowers measure 11 mm. in length and 6 mm. in diameter, fragrant.

*Calyx* 2-3-lobed at apex, at first closed and may remain so, though ripe pollen grains formed within; segments thick, greenish-yellow, ventral surface pubescent.

*Corolla* yellow, urceolate, throat very narrow (cf. *D. Embryopteris*), and appears to be frequently closed; base 6 mm. diameter, apex 3 mm. diameter; segments 4, middle line pubescent on ventral surface, 0.8-1.5 mm. thick.

*Stamens* numerous and irregular, 18-24-33, yellowish-white, unequal length, hypogynous group or terminating receptacle; *anthers* 2 mm. long, not strongly apiculate, sometimes sessile, glabrous; *filaments* 2 mm. in length, white, glabrous, sometimes absent; *pollen* isodiametric, even outline, 2 mm. diameter, show one thin part in wall.

*Pistil* rudimentary disc or absent.

*Female flowers* solitary or cymose, occurring only on the lower part of young shoots in the axil of a bract or foliage leaf; bracts green to brown, caducous, small; pedicel green, covered with short adpressed hairs, 6-10 mm. long, 2 mm. diameter, widening towards flower.

A ringed scar is noticeable on the pedicel of each flower when solitary, which is probably the area of attachment of at least two bracts at an early stage, thus suggesting a cymose inflorescence with abortive lateral flowers. Such an inflorescence is shown in pl. X., fig. 9.

*Flowers* globose-apiculate in bud, with broad base, green, hairy, 5 mm. long; remain closed for a long time as in the male.

*Calyx* 4-lobed, segments deeply divided, tapering acute apex, green, both surfaces pubescent, dorsal surface silvery in appearance.

*Corolla* yellowish-white, tubular, urceolate; segments 4, short, and triangular-shaped, with acute apices.

*Staminodes* 12-16, usually as an epipetalous ring, short, white; *anthers* broad.

*Pistil* green, tetrahedral in bud and densely pubescent; style 0, stigmas 3-4, short; ovary 4-5-6-celled.

*Fruit* oblong or subglobose with wide base and flattened top, green, glandular, and covered with short thick-walled unicellular hairs, 40-60 mm. high, 30-40 mm. diameter ; fruiting calyx enlarged, total diameter ~25 mm., flat ; segments 10 mm. long, upper surface brown or green, rounded or oblong. (See pl. X., fig. 10.)

At Hiniduma there appears to be a variety having a globose-apiculate fruit about the size of ripe fruits in *D. Ebenum* or *D. affinis*.

*Seeds* 2-4 per fruit, oval or elliptical, or wedge-shaped ; smooth brown testa, 25 mm. long, 10 mm. wide ; endosperm copious, equable. Embryo white.

*Seedlings* epigeal, cotyledons detached early, epicotyledonary system not well developed, and in seedlings 50 mm. long, very minute ; *hypocotyl* white, thick, rather short, 40-50 mm. long, suggesting affinity with *D. insignis* and *D. dodecandra*. *Don., Hinn. Ann. p. 264 (1873).* *Epicotyledonary* stem very long, 60-70 mm., longer than in any other species of *Diospyros*, suggesting *D. insignis*, except that it has no young leaves in the lower part ; first epicotyledonary leaves form an opposite pair, but at different levels ; 3 *traces* per cotyledon, 1 trace per epicotyledonary leaf ; cotyledonary xylem splits to form 10-15 groups ; epicotyledonary traces not well developed, and their courses are difficult to follow. (See pl. XVII., fig. 4.)

*Timber* red when freshly felled, deepening to reddish-brown on exposure. Black heartwood rarely of great size, usually numerous black strands irregularly distributed through the brown wood. This species is only rarely felled for the ebony it contains. (See pl. III., fig. 12.)

The tracheal elements contain abundance of a gummy deposit, yellow to brown in colour ; contents in parenchyma are brown and granular. The per cent. number of tracheal elements is low and that of the fibres high ; the differentiation of all the secondary elements is relatively constant.

Rings of growth are often conspicuous to naked eye.

*Uses*.—The ripe fruits are steeped in water and afterwards eaten by some natives. The timber of freshly felled trees

often yields large quantities of a gummy extract reputed to be efficacious for toothache.

*Distribution*.—Moist region only, 2,000 to 4,000 ft.; abundant along precipitous banks and rocky damp gullies as in Adam's Peak Wilderness and North-East Matale. Sinha Raja Forest, Hantane, Rakwana, Balangoda, Hewesse, Hini-dum, Ambalawa, Gangaruwa, Kadugannawa, Pindeniya, Gammaduwa, Pitigala, Pettiagalakanda. Also in Eastern Bengal, Silhet, Khasia.

5. **Diospyros Ebenum**, Koenig in Physiogr. Salsk. Handl. I, p. 176 (1776).

Kaluwara, S ; Karunkali, T.

Linn. f. Suppl. Pl. 440 (1781). Retz. Obs. Bot. V, 31. Thw. Enum. 180. C. P. 1,912. Hiern, Mon. Eben. 208. Roxb. Fl. Ind. II., 529. Alph. DC. Prodr. VIII., p. 234 (1844). Bedd. Fl. Sylv. Madr. t. 65 (1870). Wight, Ic. t. 188 (1840).

A large evergreen tree, dioecious, polygamous, and occasionally monœcious, trunk erect and foliage dense ; bark thick, dark grey or black, occasionally scaly, finely grooved in branches and twigs, red when cut.

*Leaves* alternate, numerous, spreading dichotomously, very variable, 50–130 mm. long, 20–60 mm. wide, oblong-oval or oblong-lanceolate, acuminate, rounded or obtuse apex, usually narrowed at base, glabrous, thinly coriaceous, bright green and shining above, paler beneath, venation strongly reticulate and pellucid, and meshes wider than in *D. Toposia*. *Petiole* 4–8 mm. long, green, glabrous.

This species could be arranged to include several varieties according to variation in size, venation, and form of the mature leaves.

The monœcious state is rarely met with. I have seen it in the forests near Dambalagala Trigonometrical Station, Central Province, at an elevation of 1,900 feet, on rocky damp slopes. At this place one tree possessed the ordinary male flowers with indefinite connate stamens and rudimentary pistil, and female flowers each with 8 barren staminodes, typical calyx, and gynæcium. (See pl. XIII., fig. 5.)



The polygamous condition is much more common, and in some districts I have often experienced difficulty in finding a true male tree. When at Vavuniya with Mr. H. P. C. Armitage in April, 1902, every tree examined in the neighbouring village compounds possessed male and hermaphrodite flowers, and the extent to which polygamy existed reminded one of *D. Gardneri*, *D. sylvatica*, and *D. affinis*. (See pl. XII., fig. 4.)

The flower systems on the polygamous trees are dichasial cymes, and more often than not the median flower is hermaphrodite; sometimes the whole inflorescence consists of male flowers only. Hermaphrodite flowers are particularly abundant where there has been excessive production of flowers in a local area; perhaps this can be correlated, physiologically, with causes similar to those which determine the frequency as median or top flower of other cymes; certain it is that female flowers occur in areas where vegetative or floral construction is at the maximum.

*Male inflorescence* consists of a dichasial cyme of 3-15 flowers (*cf.* *D. Toposia*), sessile or subsessile on lower part of young shoots in axil of caducous bract of foliage leaf; bracts small, caducous, tapering apex, green, 2 mm. long. (See pl. XIII., fig. 1.)

*Flowers.*—The buds are linear, tapering, 10 mm. long and 2 mm. diameter.

*Calyx* funnel-shaped, green, 4 mm. long; segments 4, accrescent, green, speckled with white, rounded apex, short, nearly glabrous ventrally, hairy on dorsal surface, margins ciliate.

*Corolla* tubular, yellow, throat constricted, total length 11 mm.; segments 4 (rarely 3), glabrous, narrow, thick, rounded apex, rotate, 6 mm. long.

*Stamens* numerous, 20-30, usually 16, arranged in 8 epipetalous connate groups of 2's or 3's disposed opposite and alternate to corolla segments; one group of 4 consisted of a yellow pedicel 1 mm. long bearing 2 lateral sessile fertile anthers each 2 mm. long, immediately above this

point was a third anther disposed introrsely on a short filament, and above this, terminating the connate group, was the outermost and fourth anther, introrse, on a filament 2 mm. long.

One flower contained six groups of 4, and two groups of 2 stamens; the fusion of the filaments suggests a relationship to *D. pruriens* and *D. Embryopteris*; *anthers* white or brown, glabrous, apiculate; *filaments* glabrous, except near anther. (See pl. XIII., fig. 6.)

*Pistil* rudimentary, green flattened hairy disc.

*Female flowers* (see pl. XIII., figs. 2 and 3) are solitary, subsessile, in axil of foliage leaf or caducous bract; bracts 2, green, pubescent, forming on the short peduncle an opposite pair at right angles to antero-posterior axis.

*Calyx* green, cup-shaped, 3 mm. deep, with horizontal or descending segments; segments 3-4, 9 mm. long, acute apex, glabrous or nearly so.

*Corolla* yellowish-white, total length 15 mm., throat wide; segments 3-4, rotate, broad, 9 mm. long, rounded apex, recurved when mature.

*Staminodes* 8, flattened, epipetalous, opposite and alternate to corolla segments; *anthers* 1-5 mm. long, yellow or white deltoid, apiculate, hairy apex; *filaments* white, glabrous, broad base, 2 mm. long.

*Pistil* with green or yellow style; stigmas 4-5-lobed; ovary green, glabrous, 8-celled.

*Fruit* depressed, globose or subglobose, apiculate, glabrous, green; fruiting calyx forms an enlarged shallow woody cup lined with pedicellate glandular and also unicellular hairs; the margin becomes recurved and segments project outwards and downwards. (See pl. XIII., figs. 7 and 8.)

*Seeds* 2-8 in each fruit, flattened or wedge-elliptical in shape, 14 mm. long, 6 mm. wide, 3 mm. thick; testa brown or black; endosperm hard, copious, equable; embryo white, 5-6 mm. long. (See pl. XVIII., fig. 8.)

*Seedlings* epigeal, cotyledons persistent, epicotyledonary system delayed developmentally; *cotyledons* sessile or

subsessile, green, glabrous, ovate, tapering apex, broad base. size 26-38 mm. long, and 12-19 mm. wide, palisade tissue developed early; *hypocotyl* creamy-white, turning black, 50-60 mm. long. *Epicotyledonary* stem does not appear for several weeks or months after full exposure of cotyledons; when bearing three leaves it is about 15 mm. long.

The lowest epicotyledonary leaf is always very small, ovate, with broad apex; this serves to distinguish the young seedling from those of *D. montana*. The first pair of epicotyledonary leaves are at different levels but in the same plane, cutting that of the cotyledons at right angles; *traces* 2 per cotyledon, cotyledonary xylem may or may not become diffused; 1 trace per epicotyledonary leaf, which is not continued into the root.

*Timber*.—The wood from this species supplies the greater part of Ceylon ebony; that sold as bastard ebony may come from this species or from *D. oocarpa*, *D. affinis*, &c. *D. Melanoxylon* affords an equally good black heartwood. The ebony in the stem may increase from below upwards or may repeatedly increase and decrease in volume along the length of individual trees. Ebony has been noticed in saplings and in very small two year old twigs and even in roots.

The timber is jet black or streaked, very hard and heavy, and takes a good polish; the density is very high, and according to Hiern the seasoned wood weighs 81 lb. per cubic foot, and the unseasoned 90 to 100 lb. During the last five years no less than 2,635 tons have been sold in Colombo, realizing over £22,000.

The central black wood is usually obtained by cutting away the white sapwood. If the tree is allowed to lie on the ground for many months the white wood is removed by ants; occasionally wood borers eat into the hard black wood. As to yield of black heartwood per tree, Mr. Broun states that fifteen trees, varying in girth from 6 to 12 feet, gave a gross volume of 1,208 cubic feet, out of which only 282 cubic feet

consisted of ebony. The largest log seen by Mr. Broun measured 7 feet in circumference after the sapwood was removed. The proportion of black heartwood is said to increase on poor soils.

Rings of growth are inconspicuous, though in the sapwood a zoned structure of light and dark bands is presented. The area between any two narrow dark bands varies from 0.2-8 mm. radially. The dark band possesses fibres with thick walls and reduced radial diameters; the wood parenchyma traverses these bands of thick-walled fibres without reduction in size; the tracheal elements are equally abundant in the dark and light zones. (See pl. IV., fig. 16.)

There are not sufficient reliable data concerning the rates of growth of these trees. One tree at Peradeniya measured 147 mm. in circumference on 13th August, 1900; on 1st March, 1904, it measured 180 mm.; seedlings two years old may be 900-1,200 mm. high, and about 15 mm. diameter when grown in the open. Mr. Broun states that after passing 3 feet in girth they are very slow growing, and that probably a tree reaches a girth of 18 inches (4.57 metres) at 25 years, 26 inches at 75 years, 54 inches at 135 years, and 6 feet at the age of 200 years.

The anatomy and chemistry has been dealt with in the preceding part. (See pl. XIX., figs. 1-5.)

*Uses.*—The timber is used in China for making chopsticks, pipes, and carved stands; in Europe for turnery, cabinet work, piano keys, rulers, walking sticks, brushes, and general furniture.

The gummy astringent fruits are often eaten for their medicinal and feeding properties.

*Distribution.*—Chiefly in forests of dry and intermediate zones. In the moist zone it is rare and sporadic, extending up to 4,000 feet; it is abundant in the Northern Province, especially north-east; among many other places the following may be mentioned: Colombo, Pasdun korale, Hiniduma, Hantane, Deltota, Matale, Kandy, Hewesse, Dambalagala, Pindeniya, Gangaruwa, Kadugannawa,

Ambalawa, Passara, Bibile, Viriniya, Bintenna, Vavuniya, Trincomalee, Anuradhapura. Also in South India and Malaya.

6. **Diospyros pruriens**, Dalz. in Kew Journ. Bot., Vol. IV., p. 110, n. 2 (1852).

Bu-Kaluwara, S. (see below, p. 153.)

Thw. Enum. 423. C. P. 2,836. Hiern, Mon. Eben. 185. Fl. B. Ind. III., 553. Bedd. Ic. Pl. Ind. Or. t. 129.

A small drooping or erect tree with trunk rarely exceeding 1 foot circumference, evergreen, dioecious; branches and young twigs densely coated with long stiff brown hairs, 3-5 mm. in length; bark black, rather smooth, with narrow short ridges running longitudinally, reddish-brown when cut. Leaves not abundant, alternate, 50-100 mm. long, 15-45 mm. wide; obtusely acuminate apex, rounded or subcordate base, densely covered under surface with long yellowish-brown stiff hairs, especially on the veins, midrib, and margin, upper surface glabrous except along midrib, thin, not coriaceous, pale green below, venation widely reticulate and faintly pellucid, lateral veins not strong; petiole 2-5 mm. long, reddish-brown, covered with long stiff hairs. (See pl. XIII., fig 9.)

The male inflorescence arises in the axil of a foliage leaf, and consists of a raceme of 3-4 pedicellate flowers, the oldest being at the base and youngest at the top; primary peduncle is reddish-brown, covered with long stiff hairs, 10 mm. long, 1 mm. diameter, widening towards flowers; bracts subtending pedicel of each flower reddish-brown, rounded, very hairy on lower surface, caducous, 3 mm. long.

Flowers yellow, measuring 13-25 mm. in length. (See pl. XIII., fig. 9.)

Calyx green, 8 mm. long, 5 mm. diameter at base; segments 4, thin and papery, accrescent, linear-oblong, narrow at base, tapering acuminate apex, neutral surface covered with long yellowish-white hairs 5 mm. in length.

*Corolla* yellowish-white, 13-25 mm. long, 24 mm. top diameter when flower open, throat tubular, narrow inner surface hairy, ventral surface covered with long white hairs, 2.5 mm. diameter, but shows conspicuous basal swelling, segmental portion being much longer than tube ; segments 4, rotate with basal part overlapping considerably, tapering acute apex, reddish-brown tint when mature, 13 mm. long, 6 mm. wide at base.

*Stamens* 12-14, forming hypogynous connate group terminating receptacle or surrounding hairy rudiment of ovary ; in one case the connate base of andrœcium bore 7 separate stamens, each of which had a short white curved filament and gray anther opening introrsely by longitudinal slits, and measuring 1.5 mm. long ; projecting above this was a yellowish-white pedicel 3 mm. long, which terminated in 5 sessile introrse anthers. The total length of this staminal system varies from 5-8 mm., and is the only one of its kind met with in Ceylon species. (See pl. XIII., fig. 10.)

*Pistil* absent or represented by rudimentary disc.

*Female flowers* yellow, solitary in upper axils of foliage leaves. Peduncle 16 mm. long, 12 mm. wide, covered with long stiff hairs, and often curved so as to place the flower with stigma pointed downwards.

*Calyx* green, accrescent in flower ; segments 4-5, oblong, tapering acute apex, 8 mm. long, 3 mm. wide at base, ventral surface covered with long white hairs, dorsal surface rather shiny and subglabrous.

*Corolla* yellow, tubular, constricted towards middle, 10-28 mm. long ; segments 4-5.

*Staminodes* 5 or more, epipetalous, linear ; anthers and filament glabrous.

*Pistil* greenish-yellow, densely coated with long white hairs, styles 2, separate, 4 mm. long, stigmas 4, yellow ; ovary depressed, globose, 4-celled, 5 mm. diameter.

*Fruit* solitary, globose, strongly apiculate, 20 mm. diameter, 25 mm. high, greenish-yellow, covered with long white hairs said to sting, wall thin and shrinks considerably

a few hours after fruits collected; fruiting calyx only slightly enlarged, segments inclined or nearly horizontal, thin, no cup formed, 11 mm. length, 4 mm. wide at base. (See pl. XIII., fig. 11.)

*Seeds* 1-4 per fruit, elliptical-wedge to globose-ovoid in shape; testa reddish-brown, smooth, 16 mm. long, 10 mm. wide, 10 mm. thick; endosperm equable and under great pressure in young fruits; embryo white, 6-10 mm. long. (See pl. XIII., fig. 12.)

*Seedlings* epigeal, cotyledons detached early, epicotyledonary leaves enhanced developmentally, testa does not split (cf. *D. ovalifolia*); *cotyledons* white, glabrous, square base, rounded apex, prior to detachment measure 11 mm. long, 8 mm. wide; *hypocotyl* reddish and densely covered with long white hairs (very characteristic), 70-80 mm. long, 5 mm. diameter; *epicotyledonary stem* red, 10 mm. long, first two epicotyledonary leaves form opposite pair; *traces* 3 per cotyledon, xylem of median trace equal or stronger than either lateral, diffused in lower part of hypocotyl; epicotyledonary traces 1 per leaf, weak, continued into root, but not into apical parts. (See pl. XVIII., figs. 1-5.)

*Timber* never black, but white tinged with yellow when freshly cut, on exposure turns red; heavy, compact; elements partially filled with reddish-brown deposit, low per cent. number of tracheal elements, and 78.30 to 80.99 per cent. fibres. The small size of trees of this species renders the extraction of the coloured wood, when present, unprofitable. (See pl. I., fig. 1.) The hairs on the twigs and fruits are said to possess stinging properties. F. Lewis, Esq., suggested the appropriate native name for this species.

*Distribution* limited to our wet zone, Southern Province and South-Western Province, up to 2,000 feet. This is one of our very rare species. Thwaites collected the vegetative organs only. Trimen did not see either flowers or fruits of this species. In the forests of Gilimale, Sinha Raja, Marakelle, Idikada-Mukalana, and Koskandahena the plant occurs as a sparsely foliated bushy tree, 900-1,500 mm.

high, and often a single plant is of a size convenient for a herbarium specimen. Owing to the kindness and assistance of F. Lewis, Esq., Assistant Conservator of Forests, I was able to make a tour through the Peak Wilderness, where this species proved to be very abundant in local areas. In the vicinity of Magala, Kadawatta, and Eratna, on rocky sandy soils and along precipitous streams, this species attains a height of 6,000-9,000 mm. (20-30 feet) and a circumference of about 300 mm. (1 foot). It has also been found in the Marakelle forest, Kuruwiti korale (Lewis). Also occurs in Bombay and Mysore.

7. **Diospyros attenuata**, Thw. Enum. Cey. Pl., p. 182, n. 18 (1860).

Kadumberiya, S.

Thw. Enum. 182 (1860). Fl. B. Ind. III., 561. C. P. 3,478. Bedd. Ic. Fl. Ind. Or. t. 139. Hiern, Mon. Eben. 182.

A small tree rarely exceeding  $1\frac{1}{2}$  feet in circumference and 20 feet in height, bearing flowers when trunk one inch (25 mm.) diameter; forms a mat of roots at the base; evergreen, dioecious; young shoots sparingly puberulous, quickly glabrescent; bark black, not scaly, red when freshly cut; branches and foliage present a weeping habit, branches given off low down.

*Leaves* (cf. *D. Thwaitesii*) alternate, 50-115 mm. long, 12-30 mm. wide, narrowly ovate or oblong-lanceolate, acuminate apex, narrowed or acute at base, young leaves glabrous except on under side of midrib, thin, reddish when young, green when mature, venation reticulate, feebly pellucid in young leaf, but opaque in old leaves, lateral veins fine but more conspicuous in old leaves; *petiole* green, glabrous, 2-4 mm. long. (See plate XI., fig. 15.)

Flowers and ripe fruits September to December.

*Male inflorescence* consists of a sessile cluster of 3-25 very small narrow flowers borne in axil of leaf or on old twigs; the same plant may bear flowers in successive years. Each flower is in the axil of a very small bract covered externally



with black hairs ; only rarely are the flowers solitary. (See pl. XI., figs. 10 and 11.)

*Flowers* long and narrow in bud measuring 9 mm. long and 1.5 mm. diameter, smallest flower among Ceylon species of *Diospyros*, dirty yellow in colour, usually turned downwards, and easily detached.

*Calyx* small, dark brown, pubescent, 2 mm. long ; segments 4-5, deltoid, acuminate apex, 0.9 mm. long, densely coated with dark hairs.

*Corolla* small, dirty white, diameter of open flower 5 mm., diameter at base 2 mm., covered externally with dark adpressed hairs ; segments 4-5, acuminate, rotate, subglabrous inside, 2 mm. long.

*Stamens* epipetalous, 4-6, unequal in length, glabrous (4-5 in one row, Hiern) ; *anthers* yellow, 1.6 mm. long, tapering apex, occasionally apiculate ; *filaments* white, 0.3-1.2 mm. long ; *pollen* greenish-yellow, thin smooth wall, circular, coarsely granular contents.

*Pistil* rudimentary or as central flat hairy disc.

*Female flowers* sessile and solitary in leaf axil ; in bud four-sided, pyramidal, 7 mm. long, dirty yellow in colour ; when open measures 10 mm. in length, average diameter 5 mm. (See pl. XI., fig. 14.)

*Calyx* segments 3-4-5, accrescent, brown, feeble intersegmental groove and reflexed margin, deeply divided, deltoid, thinly covered with black stiff hairs, 6 mm. long.

*Corolla* dirty yellow when fresh, red when about to drop ; projects 3-4 mm. above calyx ; segments 3-4-5, rotate, with under surface of exposed halves densely pubescent, tapering acute apex, 4 mm. long.

*Staminodes* 4-5, epipetalous, alternate with corolla segments ; *anthers* yellowish-brown, barren, glabrous, 1.2 mm. long ; *filaments* yellowish-white, glabrous, 2 mm. long.

*Pistil* yellow and covered with stiff black accrescent hairs ; 6 mm. long in mature flower ; style short, stigmas 2, black, short, each about 1.1 mm. long ; ovary pear-shaped, densely pubescent, 4-celled, 3 mm. in length.

*Fruit* ovoid-apiculate having a basal diameter of 22 mm. narrowing sharply in the upper part, then tapering gradually to an acute apex; total length 35 mm.; wall light green in colour, hairs short and sparse; calyx of fruit enlarged to total diameter of only 16 mm., not accrescent, deeply lobed thin, green, hairy. (See pl. XI., fig. 13.)

*Seeds* 2-3-4 per fruit; 25 mm. long, 10 mm. wide, 5 mm. thick; elliptical-wedge or semilunar shape; testa umber brown, smooth; endosperm copious, equable. (See pl. XI., fig. 12.)

*Seedlings* epigeal, cotyledons detached early, epicotyledonary leaves enhanced developmentally. *Cotyledons* pale colour, ovate; *hypocotyl* white turning black, 75-80 mm. long, 3 mm. diameter; *epicotyledonary* stem 20-25 mm. long; first epicotyledonary leaves form an opposite pair, leaves being broadly ovate with tapering apex, rounded base, venation reticulate and feebly pellucid, length 40-45 mm., and width 25-30 mm.; *traces* 3 per cotyledon, xylem diffuse, epicotyledonary traces 1 per leaf.

*Timber* red with small black decaying heartwood, heavy, very compact fine grain; the smallness of the tree, maximum diameter being about 160 mm. (6-6½ inches), renders it impossible for most commercial purposes; tracheal elements are narrow but irregularly differentiated, fibres abundant. The medullary rays and vessels have characteristic large lumina. (See pl. III., fig. 10.)

The coloured materials are absent from the fibres, but are moderately abundant in the medullary ray cells and vessels. The wide pits between adjacent medullary ray cells possessing coloured materials are often completely choked with the coloured material, suggesting the passage of these substances in solution from cell to cell.

*Distribution.*—This is one of our very rare endemic species, being limited to the wet forests in the south of the Island. It occurs as a very small tree along river sides in the damp forests of Wewella, Pasdun korale, about eight miles north-west of Hinidumkanda. It has also been found at

Hewessa, but nowhere else. It grows in rich clayey soil, and often accompanies *D. acuta*. When not in flower or fruit it is very difficult to distinguish from small trees of *D. Thwaitesii*.

Trees with trunks only 25 mm. diameter bear flowers and fruits. Solitary trees are rarely met with in some forests, there being a tendency for them to occur in clumps of 1-7; this must be due to some difficulty in transference of seeds; the seeds come up very freely in the forest, the primary root forming a straight axis which pierces the attenuate apex of the fruit and soon establishes itself.

8. ***Diospyros acuta***, Thw. Enum. Ceyl. Pl., p. 182, n. 17 (1860).

Thw. Enum. 182. C. P. 3,476. Fl. B. Ind. III., 561. Hiern, Mon. Eben. 182.

A small tree, largest measuring 102 mm. diameter (4 inches) and height 10.6 metres (35 feet), flowers when only 25-75 mm. diameter, evergreen, monœcious only; bark black, when freshly cut is red in colour. *Leaves* alternate, 120-250 mm. long. 30-70 mm. wide, narrowly lanceolate-oblong, tapering gradually to an obtuse or acute apex, narrowing at base, glabrous, very thick, deep green above, pale green below; venation reticulate but only feebly pellucid, lateral veins never project on either side; *petiole* stout, slightly channelled above, 25 mm. long; when not in flower or fruit very difficult to distinguish from *D. Moonii*. Flowers and fruits September to December.

*The sex* is only met with in the monœcious state; the clusters in the axil of a particular leaf usually possess all male or all female flowers; the female clusters seem characteristic of the younger leaves towards the end of the twigs (*cf.* *D. Ebenum*; *D. oppositifolia*).

Thwaites remarks that the flowers are sometimes monœcious, female above, male below.

*The male inflorescence* consists of sessile clusters of 1-7 flowers. The bract subtending each flower is green, caducous, pubescent with tapering apex, 5 mm. wide at base

and 7 mm. in length. The flowers are yellowish, 14 mm. long, average diameter in bud 3 mm., diameter of open flower 10 mm. (See pl. VII., figs. 8 and 9.)

*Calyx* brown, densely pubescent, 7 mm. long ; segments 4-5, accrescent, acute apex, 4 mm. long.

*Corolla* yellow, segments and throat covered with yellowish-brown hairs, 16 mm. long when open ; segments 4-5, rotate, very hairy on half of under surface, tapering acuminate apex, 4 mm. long.

*Stamens* 5-7-9, epipetalous, glabrous, separate or united in pairs, unequal in length ; often the inner stamen of a pair is very small and contains very little pollen ; *anthers* yellowish-brown, apiculate, 3 mm. long ; *filaments* white, 2 mm. long ; *pollen* circular, yellowish-green, thick-walled, granular contents.

*Pistil* absent or rudiment of unicellular hairs terminating receptacle.

*The female inflorescence* is sessile and usually consists of 1-3 flowers ; when solitary a pair of opposite bracts is easily seen ; when there is a sessile cyme of three flowers, it is difficult to determine the position of the bracts, which are very early caducous ; bracts larger than in male, covered with brown hairs. (See pl. VII., figs. 10-12.)

*Flowers* large and in bud measure 15 mm. long, 5 mm. diameter.

*Calyx* large, 12 mm. long, brown, both surfaces densely pubescent ; segments 5-6, lanceolate, tapering acute apex, accrescent, small intersegmental groove, margins straight, 8 mm. long.

*Corolla* yellow, large, 18 mm. long, diameter at base 6 mm., diameter of open flower 14 mm., outer surface pubescent ; segments 5-6, rotate, reflexed, hairy beneath, subglabrous above, tapering apex, base 5.5 mm. wide, length 5.5 mm.

*Staminodes* 5, epipetalous, alternate with corolla segments ; *anthers* yellow or brown ; *filaments* white.

*Pistil* large, 13 mm. long ; stigmas 2-3, reddish-brown, spathulate, glabrous, and 1.5 mm. long ; style densely pubescent, 4 mm. long ; ovary globular, apiculate, brown, densely pubescent, 4-6-celled. (See pl. VII., fig. 14.)

*Fruit* ovoid-attenuate, tapering strongly towards stigmas, 30 mm. long, 15 mm. diameter ; fruiting calyx enlarged, segments 15 mm. long, intersegmental groove and reflexed margin pronounced. (See pl. VII., fig. 13.)

*Seeds* 4-6 per fruit, flattened-elliptical, strongly acuminate at micropylar end, 22 mm. long, 7 mm. diameter ; testa umber-brown, smooth and shiny, endosperm copious, equable ; embryo white, 12 mm. long.

*Seedlings* epigeal, cotyledons detached early, 3 traces per cotyledon.

*Timber* when freshly cut is dirty white, but on exposure turns red ; small trunk, no black heartwood, heavy, compact.

The narrow lumined fibres form 88 per cent. of the elements in many parts, and the rings of growth are very inconspicuous.

The elements are never abundantly supplied with contents, the majority being not more than quarter filled : in the sapwood the contents are always yellow and in the form of globules ; in the heartwood they are of a deeper colour, occasionally granular, but never abundant. (See pl. III., fig. 11.)

*Uses*.—Only the timber is used.

*Distribution*.—This is a very rare endemic species found with *D. attenuata* in the Wewella, Wirakanda, and Hewessa forests, Pasdun korale. It has not been found outside this very wet area.

The trees usually vary from 4 to 6 metres (20 to 30 feet) in height and 25-75 mm. in diameter, the maximum size being quoted above ; they thrive best in clayey or boggy patches and like *D. attenuata* frequently occur in clumps of 3-14 trees, the leaders being matted together by dense woody roots at the base. The leaves and large stems are very similar, microscopically, to *D. Moonii*.

9. **Diospyros Gardneri**, Thw. Enum. Ceyl. Pl., p. 181, n. 12 (1860).

Kadumberiya, Kallu, S.

Thw. Enum. 181. C. P. 1908. Fl. B. Ind. III., 561. Bedd. Ic. Fl. Ind. Or. t. 132. Hiern, Mon. Eben. 182. 14.

214/ A moderate-sized or large tree, evergreen, dioecious and polygamous; branches glabrous, young twigs pubescent; bark black, thick, when freshly cut yellowish-red. *Leaves* very variable in size and form, alternate, 75-180 mm. long, 25-55 mm. wide, oblong or oval-lanceolate, acuminate apex, narrowed at base, glabrous and shining, thinly coriaceous, deep green above, paler green beneath, venation reticulate, pellucid, bullate, lateral veins prominent beneath; *petiole* 7-25 mm. long, slightly pubescent below.

The peduncle is usually curved so as to bring the flowers directed downwards, in which case they are partially protected from sun, wind, and rain by the leaves.

*Sex*.—Some trees are male only, others female only, and others polygamous; several of the latter group are growing at Peradeniya.

The polygamous condition may be observed on many trees growing at Peradeniya, and has been determined for three years in succession; the flowers on polygamous trees may be grouped as follows: (a) those with short accrescent calyx segments, fertile anthers, and abortive apiculate pistil; (b) those with large deltoid calyx segments, margins of which are straight or recurved, fertile anthers, and abortive apiculate pistil; (c) those with large deltoid calyx segments with deep intersegmental grooves, fertile anthers, and fertile pistil producing seeds. Hence the series from male to hermaphrodite flowers on the same tree is gradual and complete. (See pl. XII., figs. 1-8.)

The accessory whorls exhibit very few external characters which enable one to distinguish the male from hermaphrodite flowers. The enlarged recurved calyx segments are the best external indications of a hermaphrodite flower, but

these characters may be absent in such flowers, or may be occasionally present in male flowers.

The development and anatomy of the seedlings was originally studied from seeds obtained from the polygamous trees.

The male and hermaphrodite flowers occur separately or as members of the same axillary inflorescence (*cf.* *D. sylvatica* and *D. Ebenum*).

*Male inflorescence* consists of sessile and subsessile pubescent cymes; developmentally it first appears as a red pubescent bud in the axil of a leaf with or without a peduncle; on either side at right angles to the antero-posterior axis a bract appears, each subsequently bearing a flower in its axil. After a long interval another pair of opposite bracts appear in a plane at right angles to the first, followed by a flower in the axil of each. The primary flower occupying the centre of the inflorescence may be subsessile or supported on a peduncle 10 mm. in length, but each subsequent flower is always sessile. Further complications follow in consequence of the development of pairs of flowers around each of the subsequent flowers mentioned above. Peduncle 1-2-10 mm. long, green, pubescent; bracts small, 2.5 mm. long, 2 mm. wide, caducous, tapering apex, pubescent. (See pl. XII., fig. 5.)

*Calyx* green, ventral surface pubescent, 5 mm. long; segments 4, 3 mm. long, accrescent, deltoid, acuminate apex, straight or slightly recurved margin.

*Corolla* yellow, conical in bud, 10-13 mm. long, tube inflated; segments 4, half the length of tube, spreading, glabrous inside, silky pubescence outside.

*Stamens* 12-16, epipetalous or monadelphous hypogynous group, separate or connate in pairs, inner series always shorter than outer; when 12 only they are usually as 4 pairs and 4 singles, the former being divisible into an outer and inner series; *anthers* inner series 3 mm. long, apiculate.

glabrous or slightly pubescent, 1–5 mm. long; *pollen* yellow, even circular outline. (See pl. XII., figs. 9 and 10.)

*Pistil* absent or represented by a flattened apiculate disc which often shows in transverse section a crude celled structure.

*Female flowers* are solitary in axil of leaves, sessile or subsessile; peduncle 4 mm. long, and possesses two pairs of bracts which never bear flowers in their axils, but from comparison one may perceive a similarity with a cymose inflorescence in which all except the primary flower abort (*cf.* D. Embryopteris); first pair of bracts brown, near base of peduncle and at right angles to antero-posterior axis; second pair green, hairy, and at right angles to the first. (See pl. XII., figs. 11 and 12.)

*Calyx* green, openly campanulate, pubescent; segments 3–4, usually 4, 10 mm. long, deltoid, margin recurved and undulated so as to form a ridge, 2 mm. wide, projecting outwards and downwards, tapering apex.

*Corolla* white or yellow, tube 8 mm. wide, when mature 15 mm. long and 10 mm. diameter at top, silky pubescent beneath; segments 3–4, 7–10 mm. long, 2 mm. wide, strongly reflexed or spreading in open flower.

*Staminodes* 8, epipetalous, opposite and alternate with corolla segments, 5 mm. long, 0.5 mm. wide; *filaments* white, hairy, 3 mm. long, adnate to corolla tube at base; *anthers* white, barren. (See pl. XII., fig. 13.)

*Pistil* with stigmas 3–4, greenish-white; style persistent, 5 mm. long; ovary globose-apiculate, pubescent, 8-celled.

*Fruit* solitary, green, nearly glabrous, depressed-globose, apiculate, yellow when ripe, 35 mm. high, 25 mm. diameter; fruiting calyx enlarged and hemispherical, deep undulating intersegmental grooves, cup for fruit 15 mm. deep. *Seeds* usually 8 per fruit, thin and flattened, micropylar end slightly recurved, antipolar end straight or rounded, 15–18 mm. long, 8–10 mm. wide, 2 mm. thick; testa olive-brown, shining, not streaked; endosperm copious and equable; embryo white and measures 17 mm. in length.



*Seedlings* epigeal, cotyledons persistent, epicotyledonary system late in development; *cotyledons* pale green, 40 mm. long, 20-30 mm. broad, cordate, tapering apex, rounded base; *hypocotyl* erect, 90 mm. long, 2-3 mm. diameter, glabrous, becomes black and four-cornered; *epicotyledonary* system does not appear until several weeks or months after cotyledons fully developed; *epicotyledonary* leaves are alternate and measure 25 mm. long, 12 mm. wide, glabrous, deep green, coarse bullate venation; 2 *traces* to each cotyledon, xylem split considerably; epicotyledonary traces 1 per leaf, not continued into root.

*Timber* yellow with occasional black strands, inferior; similar to *D. sylvatica*; wood parenchyma wide lumined, tracheal elements rather low percentage number; large radial strands of parenchyma occur in the wood (*cf.* *D. quæsita*); the coloured contents are not abundant; timber used for buildings. The wide lumined parenchyma and the sparse contents of the secondary xylem elements prove the timber to be of inferior quality. (See pl. II., fig 7.)

*Distribution* limited to wet and intermediate zones of Ceylon, up to 2,500 feet; Colombo, Ratnapura, Kurunegala, Hantane, Gangaruwa, Ambalawa, Karawita, Sinha Raja forest, Pindeniya, Eratne, Gammaduwa.

10. **Diospyros oocarpa**, Thw. Enum. Ceyl. Pl., p. 180, n. 9 (1860).

Kalu kadumberiya, Eta timbiri, S.; Vellai karunkali, T. Thw. Enum. 180. C. P. 1,914.

Fl. B. Ind. III., 560. Hiern, Mon. Eben. 171.

A moderate-sized or large tree, evergreen, dioecious; bark thick, dark surface, yellowish when cut, young shoots faintly pubescent; flowers in April, fruits in September.

*Leaves* alternate, 50-90 mm. long, 25-50 mm. wide, ovate or oval, obtusely acuminate at apex, rounded at base, glabrous and shining, thinly coriaceous; venation widely reticulate and faintly pellucid, but inconspicuous in old leaves; *petiole* flat, 5 mm. long. (See pl. VII., fig. 7.)

*Male inflorescence* consists of an axillary dense sessile or sub-sessile cyme, each flower being subtended by a concave rounded bract.

*Flowers* bomb-shaped, tapering from base to apex and measuring 12 to 25 mm. when unopened. (See pl. VII., fig. 1-3.)

*Calyx* green, faintly pubescent, forming a cupule 5 mm. high and 4 mm. diameter ; segments indistinct with margins forming an even outlined rim.

*Corolla* yellow, throat narrow, 13 mm. long ; segments usually 3, long and tapering, 6 mm. long, reflexed when flower mature. One of the segments is completely enclosed by the others in bud, the other lobes imbricating sometimes dextrorsely and at other times sinistrorsely (Hiern).

*Stamens* indefinite, 9-11-12-14, epipetalous or hypogynous, unequal, not apiculate, in pairs or single ; *anthers* brown, hairy, 1 mm. long ; *filaments* white, glabrous, 0.5-2 mm. long ; *pollen* yellow, circular.

*Pistil* represented by rudimentary hairy disc or absent.

*Female inflorescence* consists of sessile cluster of 3 flowers ; sometimes the flowers are solitary ; bracts very small and caducous. (See pl. VII., fig. 4.)

*Flowers* bomb-shaped when young, 12 mm. long, 4 mm. in diameter.

*Calyx* brownish-black, thin, glabrous or feebly hairy, forming a cupule 5-7 mm. high ; segments indistinct, agreeing with male calyx ; calyx of quite specific type.

*Corolla* greenish-yellow, tapering to apex, 15 mm. long ; often closed ; segments 3, not very distinct, short, walls very thick.

*Staminodes* 3, epipetalous, very short, total length being 0.5 mm. ; *anther* barren, brown or yellow, hairy towards apex ; *filament* white, glabrous and about one-third the length of anther.

*Pistil* brown, hairy, small ; stigma single or bifid, short ; ovary 6-celled.

*Fruit* oblong-ovoid, 35 mm. high, 23 mm. average diameter, wider at the top than towards calyx, rounded at top, apiculate; carpellary wall green, glabrous, uneven surface first being papillate and finally strongly lobulate, the lobes being conspicuous in one seeded fruits; usually 4-6-celled, one seeded; fruiting calyx slightly enlarged, flat, circular, total diameter 11 mm., persistent, glabrous, black. (See pl. VII., fig. 5.)

*Seeds* flattened, elliptical, with two longitudinal grooves running along the surface, or tending to become as broad as long with a beaked micropyle and as many as five deep longitudinal grooves; form different from all other species; average length 25 mm., width 15 mm.; testa brown, shiny; endosperm copious, horny, equable; embryo white, 11 mm. long.

*Seedlings* epigeal, cotyledons detached early, epicotyledonary leaves slightly enhanced developmentally; *cotyledons* narrow, yellow, 12 by 4 mm.; *hypocotyl* short type, 10-30 mm. long, 2.5 mm. diameter, at first white, but soon turns brown and black; epicotyledonary stem long, slender type bearing several small leaves along its length at intervals of about 10-20 mm.; at a distance of about 40 mm. the large leaves are borne alternately; stem greenish, densely pubescent; epicotyledonary leaves lanceolate-ovate, even surface, glabrous above except along midrib, pubescent beneath, venation faintly pellucid; veins not prominent on either side, widely reticulate, petiole short; *traces* three per cotyledon, xylem splits into 8-13 strands; one trace per epicotyledonary leaf, continued below cotyledonary node.

Developmentally and morphologically these seedlings are, in many respects, like those of *D. insignis*. The epicotyledonary leaf rudiments suggest *Garcinia*.

*The timber* is very variable. The young trees have usually a small black or brown heartwood, and a sapwood of a faint red tint; large trees possess a coloured heartwood of considerable size; one tree having a total diameter of

690 mm. had a heartwood 440 mm. diameter. The heartwood of such trees is invariably irregular in outline and presents a beautiful alternation of black and brown layers, which from an ornamental point of view greatly enhances the value of the timber; such specimens are almost equal to calamander for ornamental purposes. The sapwood of large trees may possess irregular dark lines, which in longitudinal section give good patterns to the coloured timber. The coloured materials occur in all elements of the sapwood except the fibres. The contents of the parenchyma cells is at first granular, but when these granules have disappeared the coloured contents take on the appearance of a gum-resin. In the heartwood all the elements, fibres included, become filled with brown or black contents, with or without a change in the colour of the walls of the elements. The only clear lines in a transverse section of the black heartwood are those of the medullary rays, the comparative clearness of this tissue being due to the thinness of their walls and the partial exhaustion of contents.

Anatomically the timber is characterized by abundance of closely set fibres, and large tracheal elements, and a low percentage number of medullary ray cells. The differentiation is very irregular. Rings of growth are very inconspicuous.

The timber of this tree is rarely met with, and may in some cases furnish the bastard ebony of commerce. (See pl. IV., fig. 15.)

*Distribution* rare in the dry and intermediate zones; Haragama, Uma-oya, Kurunegala, between Nalanda and Dambulla, Maturata, Kalugalla, Mihintale.

Also in Konkan and Babaloodun hills, Mysore.

// **Diospyros quæsitæ**, Thw. Enum. Ceyl. Pl., p. 179., n. 7 (1860).

Kalamediriya, S., Calamander.

Thw. Enum. 179. C.P. 3,010. Fl. B. Ind. III., 560. Bedd. Ic. Pl. Ind. Or. Pt. VII., p. 26, t. 128 (1871). Hiern, Mon. Eben. 174.

A large slow-growing evergreen tree, dioecious ; trunk erect and feebly buttressed ; branches dark and spreading ; bark blackish-gray, 12 to 20 mm. thick in very old trees, peels off in thin sheets exposing brownish layer beneath ; bark of twigs shows irregular, narrow, longitudinal ridges ; young twigs stout, green, glabrous.

*Leaves* alternate, 75-180 mm. long, 40-80 mm. wide, oblong-oval, or oblong-lanceolate, shortly acuminate obtuse apex, glabrous, coriaceous ; venation feebly pellucid in young leaves, lateral veins inconspicuous, nearly horizontal, prominent when dry ; *petiole* 12-20 mm. long, stout, flattened, and canaliculate above.

*Male inflorescence* occurs in axil of foliage leaf or small caducous bract ; in former case there is often congenital concrescence of peduncle and stem for a distance of several mm. ; flowers 3-9 on drooping pedicels along the length of primary peduncle at very irregular distances, the first flower occurring at the base or 20 mm. above the base ; primary peduncle green, stout, very variable length ; each flower is pedicellate and subtended by a caducous bracteole. Each pedicel bears an opposite pair of small bracteoles ; pedicels green, slightly pubescent, wide towards flower, 6 mm. long, 1.5 mm. diameter ; bracteole subtending pedicel green, pubescent, sessile, tapering obtuse apex, rounded base, caducous, 8 mm. long, 2 mm. wide ; basal bracteole and axis green, covered with long unicellular hairs, lanceolate, tapering apex, 4 mm. long, early caducous leaving small scar. Hence there appears to be an inflorescence, which though now approximating to a raceme, possesses the rudiments of a dichasial cyme. (See pl. VI., fig. 7).

The flowers are often closed when the mature pollen is ready for dispersion ; the diameter of open throat is small (*cf.* D. Toposia).

*Calyx* green, forms deep cup for floral parts and in bud is elongate-oval, 9 mm. long, 4 mm. diameter ; segments pubescent, deltoid, acute apex.

*Corolla* yellow, tubular, thick, narrow-throated, basal part swollen, 12 mm. long; segments 4-5, rotate, pubescent beneath, broadly ovate, sub-acute apex.

*Stamens* indefinite, or about 16, terminating receptacle, 3 mm. long; *anthers* yellowish-brown, nearly sessile, attenuate and pubescent apex; *filaments* white, short, glabrous; *pollen* thin-walled, yellowish-white, feebly granular contents.

*Pistil* absent or rudimentary.

*Female flowers*.—My first fresh material was obtained through the kindness of F. Lewis, Esq., from Nahitimukalana, Atakalan kōrale, 1,800 feet above sea level.

*Flowers* solitary, pedunculate in axil of foliage leaf, or on lower part of young shoots in axil of caducous bracts; in bud 5 mm. long, 8 mm. diameter, resembling in appearance those of *D. Melanoxylon*. Open flower measures 20 mm. long, average diameter 3 mm. The peduncle is green, pubescent, measures 20 mm. in length, and bears two small caducous bracts at right angles to antero-posterior axis. (See pl. VI., fig. 5.)

*Calyx* brown, covered with dense layer of velvety hairs; segments 5, acute apex; when young, margin slightly recurved, but later very wide intersegmental grooves are formed. These pouches are at first nearly horizontal, but subsequently widen and become strongly reflexed, the apices of the segments remaining erect and in contact with corolla.

*Corolla* yellowish-white, pubescent, 15 mm. long, 12 mm. diameter; segments 5, obtuse or rounded apex, recurved in old flowers, 5 mm. long, 5 mm. wide at base.

*Staminodes* 5, epipetalous, alternate with corolla lobes and 2 mm. in length, occasionally smaller epipetalous alternating structures occur, probably rudimentary or abortive staminodes; *anthers* barren, yellowish-brown, bluntly apiculate; *filaments* white, short, glabrous.

*Pistil* green, pubescent, 6 mm. long, 5 mm. diameter; stigmas 5, green, short, undulating apices; ovary 10-celled.

*Fruit* large, 60–75 mm. long, 50 mm. diameter, sub-globose or ovate, slightly flattened at top, apple-green to black, glabrous or nearly so; fruiting calyx enlarged, flattened, woody, intersegmental groove large, margins strongly reflexed. (See pl. VI., fig. 8.)

*Seeds* 4–10 in each fruit, 30 mm. long, 15 mm. wide, 5 mm. thick, flattened and elliptical in shape; testa brown, shining, striated; endosperm copious, horny, equable. (See pl. VI., fig. 9.)

*Seedlings* epigeal, cotyledons detached early, epicotyledonary system enhanced in development and distinguishable in resting embryo (see pl. VI., fig. 6.); *cotyledons* white, when mature measure 25 mm. long, 12 mm. wide, oblong-ovate, blunt apex, squarish base, strong midrib; *hypocotyl* yellowish-green, rapidly turning black, glabrous or nearly so, 90–100 mm. long, diameter 3 mm.; *epicotyledonary* stem yellowish-red, 3 mm. long; *epicotyledonary* leaves, first two form an opposite pair at right angles to the plane of the defunct cotyledons, 60 mm. long, 30 mm. wide; *traces* 3 per cotyledon, median abortive, xylem not much split; epicotyledonary traces, one per leaf, probably continued into the root.

*Timber.*—The timber of this species—calamander—is considered to be one of the best for durability and ornamental purposes. It would be difficult to find a prettier variegated wood, though samples of *D. Kurzii*, received from the Conservator of Forests, Andaman Islands, come a good second for ornamental value.

The timber is very scarce; the total amount exported from Ceylon during the last five years being 20 pieces only; these were sold in Colombo for Rs. 150. The specimens were in the form of planks, slabs, and small round pieces, the latter measuring 3 to 4 feet in length and 16 inches in circumference.

The heartwood, when present, is usually of a deep brown colour streaked with black. There is however, considerable uncertainty as to the presence and abundance of coloured

*Hern. n. n. p. 162 (1873)*

heartwood, and many very old trees have been felled which possessed only dirty white or brownish timber, which was therefore as useless as that obtained from *D. Moonii*. (See pl. V., fig. 17.)

The relative value of samples of calamander is determined by the quantities of coloured material filling the cells; it is not due to a particular type of histological differentiation. The black portions of calamander are not more durable than the heartwood of *D. Melanoxylon* or *D. Ebenum*; the deep brown portions are considerably less so. The value of calamander over other *Diospyros* woods is due to the particular abundance and more general distribution of the colouring materials characterizing the species.

The percentage of fibres varies from 80-86 per cent.; additional strands of parenchymatous tissue occur in the xylem (*cf.* *D. Gardneri*).

The rings of growth are inconspicuous.

The timber of *D. oocarpa* and *D. affinis* sometimes approximates to calamander in point of distribution of coloured substances in the central timber. In these two species, however, there is always a large proportion of useless sapwood.

*Uses.*—In addition to the timber being used whenever procurable, the ripe gummy fruits are eaten by the natives.

*Distribution* endemic, rare, this species being found only in the moist low-country up to 2,000 ft. The scarcity of this tree is not alone due to the value put upon its timber, but (a) to a curious mode of development, resulting in the death of many of the germinated seeds, (b) to the very slow rate of growth in the seedling and later stages; two-year-old saplings measure only 600 mm. (less than 2 feet) in height, and trees over 60 years old have a circumference of 472 mm. (19 inches) only, (c) to the dioecious flower system and the long interval between flowering periods.

There are a good number of trees on Hinidumkanda, and also in the Sinha Raja forest; Potapitiya, Kukulukorale;



Kuruwiti korale ; Ratnapura, Dotalankanda, Pasdun korale ; Yagiralla, near Udugama ; Nahitimukalana, Atakalan korale ; Pennelmukalana, Madampe district.

The trees grow well on rocky, porous, damp slopes, rich in silica and iron ; they vary from 0·6 to 2·4 metres (2-8 feet) in circumference, and 12 to 24 metres (40-80 feet) in height.

The largest specimen I have seen measured twelve metres (40 feet) before the first branch, total height 27·4 metres (90 feet), and breast height circumference of 2·4 metres (8 feet); this was a male tree, Yagiralla forest, 900 feet above sea level.

/2. **Diospyros sylvatica**, Roxb. Cor. Pl., p. 37, t. 47 (1795)

Sudu-kadumberiya, S ; Karuppu Thoveria, T.

Alph. D.C. Prodr. VIII., p. 231. (1844). Thw. Enum. 178. C.P. 2,729, Fl.B. Ind. III., 559 Bedd., Ic. Pl. Ind., Part VII., p. 25, t. 121 (1871). Hiern, Mon. Eben. 161.

A very large tree, attaining a circumference of 4 metres (13½ feet) and height of 61 metres (200 feet), evergreen, diœious and polygamous ; trunk erect, buttressed at base, bark of twig shows coarse reticulation, bark of trunk blackish-gray, thick. *Leaves* alternate, 70-130 mm. long, 20-60 mm. wide, oval, acuminate apex, narrowed or rounded at base, glabrous or nearly so ; young leaves thin, old leaves coriaceous, deep green above, paler beneath ; venation reticulate, meshes wide, pellucid, midrib and veins depressed on upper side ; *petiole* flattened, feebly puberulous, 5-12 mm. long.

*Polygamous trees*.—These are very similar to *D. Gardneri* and *D. Ebum*.

The seeds and seedlings from polygamous trees possess the same characters, anatomically and developmentally, as those obtained from pure female trees. All the flowers on these trees possess fertile stamens and a rudimentary or fertile pistil, those with fertile pistils being usually accompanied with larger accessory whorls. The absence of flowers with fertile pistils during the first few weeks of flowering has been noticed, and it seems quite probable that the production

of unisexual and hermaphrodite flowers may be effected during different periods. There is also a tendency for the hermaphrodite and unisexual flowers to occur in separate clusters, though the mixed condition in the same inflorescence has been noticed (see pl. XI., fig. 4-6). The flowers are strongly aromatic, and Mr. Willis informs me that they are visited by many bees at Peradeniya.

*Male inflorescence* arises on lower part of young shoots in axil of caducous bract or foliage leaf; when the latter the clusters are more crowded and abundant. The bud is enclosed in a sheathing bract; two small bracteoles appear on the primary peduncle at right angles to the antero-posterior axis, and in the axil of each a flower appears. Each lateral flower becomes the median flower of another cyme, and this is repeated until we have a crowded dichasial cymose inflorescence of 7, 15, or more flowers on a peduncle only 7-10 mm. in length. The first pair of lateral flowers have pedicels over 2 mm. in length, but the subsequent flowers are subsessile along their respective axes; bract subtending inflorescence green, hairy, caducous, 6-10 mm. long; the bracteoles are much smaller, green, hairy, caducous; flowers in April, fruits September-February. The inflorescence attains a length of 20 mm. and is similar to the male of *D. Ebenum* and *D. Toposia*. (See pl. XI., fig. 1-2.)

The *flowers* are small, white, fragrant and openly bell-shaped.

*Calyx* green, total height 3 mm.; segments 3-4, pubescent or ciliate, rounded apex, accrescent, 1 mm. long.

*Corolla* white, urceolate or campanulate, total height 8 mm., diameter at top 8 mm.; segments 3-4, rotate, glabrous, rounded apex, 3 mm. long.

*Stamens* irregular, 13-22, epipetalous, single or united in 2's or 3's forming usually about 8-10 groups; when in pairs the shorter anther is innermost (*cf.* *D. Gardneri*); *anthers* yellow, introrse, shortly apiculate, dehiscing laterally from apex; *filaments* white, united or separate, glabrous except near base of anther.

*Pistil* absent or rudimentary, flat disc, 2 mm. diameter, undulating, exhibits locular structure.

*Female flowers* solitary, or as a cyme of 3 flowers on peduncle of varying length ; pedicels of each flower short, bracteate. (See pl. XI., fig. 8).

*Calyx* green, 12 mm. diameter ; segments 3-4-5, rounded apex, 8 mm. long.

*Corolla* yellowish-white, 11 mm. long ; segments 4. rounded apex, 3 mm. long.

*Staminodes* 4, epipetalous, alternating with corolla segments, glabrous, white.

*Pistil* 3 mm. long, 2 mm. diameter ; stigmas 3, deep green, glabrous ; ovary 6-celled, broad base, tapering apex, green, glabrous.

*Fruit* globose, smooth, dark gray, 12-20 mm. high, 10-15 mm. diameter ; fruiting calyx enlarged, flat or accrescent, thin and not woody, 15-20 mm. diameter.

*Seeds* 2-4-6 per fruit, 14 mm. long, 10 mm. wide, 6 mm. thick ; ovate or globose in shape ; testa brown, streaked ; endosperm abundant, strongly ruminant and very rich in tannin ; embryo white and small, 6 mm. long. (See pl. XI., fig. 7).

*Seedlings* epigeal, cotyledons persistent. The whole or greater part of the endosperm is absorbed before the testa splits ; *epicotyledonary* system does not appear until several weeks, and in one case five months after cotyledons mature.

*Cotyledons* cordate, rounded base, tapering obtuse apex, glabrous, 25 mm. long ; *hypocotyl* red, glabrous, thin, 80 mm. long ; *epicotyledonary* stem very short and developed at a late stage ; *epicotyledonary* leaves—first leaf appears about 1 mm. above cotyledonary node, second about 2 mm. above first ; alternate, deep green, tapering strongly towards base, rounded apex, venation feebly pellucid, 20 mm. long, 11 mm. maximum width ; *traces* two per cotyledon, xylem splits forming 8-15 groups ; one trace per epicotyledonary leaf, not prolonged into root. Below the collet most seedlings show a

crude octarch exarch cylinder with protoxylem groups joined by strongly lignified perimedullary zone. (See pl. XVII., fig. 5, 6).

*Timber* when freshly felled is yellow or white with a variable but usually small quantity of black heartwood; inferior but often used for fancy work and buildings. The yellow colour (*cf.* *D. Gardneri*) is due to the preserving, in very small quantities, of brown or yellow contents in the parenchymatous and tracheal elements. The medullary ray cells of the sapwood possess contents some of which show signs of disintegration and acquire a distinct colour in passing to the heartwood. The number of parenchymatous cells with such contents increases considerably from without inwards and in addition many of the vessels become partially filled with gum-resin of a yellow colour. (See pl. II., fig. 7). The differentiation of the elements is fairly regular; the percentage number of fibres is rather high. This species is only rarely felled for its timber. The rings of growth are visible to the naked eye; sometimes they have a radial diameter of 1 mm. but occur at very irregular distances from one another.

*Uses.*—The timber though inferior in quality is sometimes used in fancy work. The fruits when ripe are a trifle fleshy; they are occasionally eaten.

*Distribution* rather rare and limited to the wet zone up to 4,000 feet; Hantana, Gangaruwa, Watagoda, Ekneligoda, Ambalawa, Sinha Raja forest.

Also in S. India.

13. ***Diospyros Melanoxylon*** Roxb. Cor. p. 36, t. 46 (1795).

Kadumberiya, S.

Alph. D. C. Prodr. VIII., p. 224 n. 7 (1884). Fl. B. Ind. III., 564.

Roxb. Cor. Pl. t. 46. Hiern, Mon. Eben. 159.

A medium-sized or large tree, evergreen, dioecious (polygamous?); bark deeply fissured in alternate grey and black layers, fissures running vertically for a great distance; 100

mm. long, 20 mm. wide ; the bark is 10 mm. in thickness on branches 40 mm. diameter ; young twigs green, pubescent, become glabrous, white and shiny.

*Leaves* very variable in position and size ; usually opposite, sometimes sub-opposite or alternate, often crowded at end of twig, 40-140 mm. long, 15-70 mm. wide, (on suckers the leaves are often 240 mm. long and 100 mm. wide), oblong-oval, rounded or obtuse apex, tapering base, pubescent when young, glabrous and shiny when old, under-surfaces duller green than upper ; venation reticulate, meshes wide, pellucid ; lateral veins not very conspicuous above, prominent below ; *petiole* green, glabrous or hairy, flat above, 4 mm. diameter, 15 mm. long.

*Male inflorescence* usually consists of a dichasial cyme. 3-7-flowered, similar to that described for *D. sylvatica*, *D. Toposia*, &c., and occurs in lower part of young shoot in axil of leaf or caducous bract ; sometimes the lateral flowers do not arise in opposite pairs but at different levels suggesting a racemose type. (See pl. VIII., fig. 8).

When the inflorescence is represented by a central flower only, the bracteoles are nevertheless present ; the flowers which should occur in the axil of bracteoles in the plane of the antero-posterior axis are commonly absent.

The main peduncle is pubescent, 3-11 mm. long, 2 mm. diameter ; pedicels of first pair of lateral flowers longer than those of second pair and measure 15 mm. in length and 2 mm. in diameter ; bracts and bracteoles long, pubescent, size gradually decreasing from bract to youngest bracteole.

*Male flowers* in bud are green, pubescent, 5 mm. long, 3 mm. diameter ; open flower 13 mm. long ; there is much variation in the number and orientation of the members of accessory whorls and stamens.

*Calyx* yellowish-green, pubescent, campanulate, 5-8 mm. long, 5 mm. diameter, occasionally very small ; segments 3-6 and accrescent, apex acute, 1.5-3 mm. in length.

*Corolla* yellowish-white, narrow-throated, outside covered with silky hairs, 12 mm. long, 3 mm. diameter : segments

4-6, usually 5, rotate, rounded or acuminate apex, 2 mm. long, 2 mm. wide.

*Stamens* indefinite, 8-10-16-20, never epipetalous but terminate central disc, arranged singly or in equal or unequal groups of 2 or 3; in one case 15, arranged (*a*) outer whorl of 8, four in two connate adjacent pairs, and four successive separate stamens: (*b*) inner whorl of 7, two of which were connate (*cf.* *D. pruriens*); in another case 13, ten in 5 pairs with anthers of inner stamens shorter than outer, two as a pair with anthers of equal length, and one separate stamen with long anther and filament; *anthers* yellow, glabrous, slightly apiculate, 1.8-3 mm. long, opening by longitudinal slits; *filaments* white, glabrous, 1.5-2.5 mm. in length.

*Pistil* absent or represented by bunch of hairs or apiculate rudiment 2 mm. long.

In one or two cases I suspected polygamy, but was not able to prove the undoubted occurrence of this condition.

*Female flowers* solitary in axil of foliage leaf, large; in bud measure 5 mm. in length and 6 mm. in diameter; accessory whorls very unequal; peduncle short and stout, covered with light brown hairs, 1.5 mm. long, 3 mm. diameter; two small hairy bracteoles on peduncle forming an opposite pair at right angles to antero-posterior axis (*cf.* *D. affinis* and *D. Ebenum*) 2mm. long, broad base, acute apex; occasionally a third bracteole occurs placed between flower and axis. (See pl. VIII., fig. 6).

*Calyx* green to brown, deeply lobed, pubescent, forming rather shallow cup; segments 4-7, usually 6, accrescent, tapering apex, broad base, margins undulate, 7 mm. long, 5 mm. wide, become more nearly horizontal after fertilization.

*Corolla* yellow, wide-throated, white base, both surfaces covered with silky hairs, 9 mm. long, 5 mm. diameter; segments 5, tapering apex. 3 mm. long, 2.5 mm. wide.

*Staminodes* indefinite 8-10-12, rarely epipetalous, when 12 in number they are opposite and alternate to calyx segments; *anthers* reddish-brown, barren, apiculate, glabrous, 1.5 mm. long; *filaments* yellowish-white, glabrous, 2.5 mm. long.

*Pistil* green, globose, densely pubescent; stigmas 4, green, hairy, and fleshy; *ovary* globose, 7 mm. long, 4 mm. diameter; 4-6-celled, but orientation of loculi very irregular; ovules usually disposed at right angles to the plane of antero-posterior axis and this apparently in consequence of pressure.

*Fruit* solitary, green, globose-apiculate with few persistent hairs, 40 mm. high, 30 mm. diameter, 2-4-celled: fruiting calyx slightly enlarged, 25 mm. diameter, pubescent, reflexed and undulated margin, small intersegmental groove; acute apex of segment remains in contact with carpellary wall. (See pl. VIII., fig. 7).

*Seeds* 1-4 per fruit, oval-wedge shape, 21 mm. long, 10 mm. wide, 8 mm. thick; testa reddish-brown; endosperm copious, horny, ruminate; embryo white, 15 mm. long.

*Seedlings*.—None of the seeds germinated, but from a study of the embryo the following points were made out:—Traces three per cotyledon, epicotyledonary traces prominent and distinguishable in the resting embryo. The seedlings are very probably of the ordinary epigeal type with cotyledons which become detached at an early stage.

*Timber*.—This species is one of the main sources of Indian ebony, possessing very durable black or streaked heartwood. It is spoken of as Coromandel wood by Dr. Watt (Econ. Prod.) and it is difficult to understand why Trimen (Fl. Ceyl., p. 99) refers to it as inferior to that of *D. Ebenum*. The majority of the trees still in Ceylon are certainly small and cannot yield much good heartwood. In one large tree trunk 320 mm. diameter the black heartwood measured 120 mm. in diameter; in another stem 270 mm. diameter, the heartwood measured 110 mm. diameter—a proportion which compares favourably with *D. Ebenum*. (See pl. I., fig. 5).

The contents of the parenchymatous and tracheal elements are, as one might expect, always conspicuous. In the red sapwood the coloured contents are almost limited to the medullary ray cells, but in the black heartwood every element is filled with reddish-brown materials. A discolouration also appears in the walls.

The differentiation of the elements is comparatively regular. The percentage number of fibres is approximately 81, and the maximum variation is presented in the cells of the wood parenchyma. Insignificant rings of growth can be distinguished, sometimes continuous throughout the section, at other times on one side only. I believe that if old trees of this species were only more abundant we should have a valuable source of ebony, quite equal to *D. Ebenum* from an economic point of view. Its limited distribution in Ceylon is not due to non-production of fruit.

*Distribution.*—This species is very rare in Ceylon. It was first found between Bibile and Ekiriankumbura, Uva, in 1888. It was unknown to Thwaites and according to Trimen (Fl. Ceyl. p. 99) there were no known specimens from the Island except from the above locality. The flowers were first obtained in Ceylon, in May, 1901.

It occurs on the patana and coarse forests to the south-west of Bibile in the localities Elukkapudena, Antibuwana, and Diggalarana. At the first-mentioned place at an elevation of 700–900 feet, the tree is found on patana ground, and there rarely exceeds a total height of 9.1 metres (30 feet) and breast height circumference of 305 mm. (1 foot), though the trees are probably very old. At the latter places, the tree reaches a height of 18.3 metres (60 feet) and circumference of 1–1.67 metres (3½ feet—5½ feet).

Other trees also occur along the Bibile-Bintenna road, near Bibile, at the base of a small hill.

*Uses.*—The Sinhalese call the tree Kadumberiya in this district. They collect the unripe fruits and after steeping them in water for two to three days, pronounce them fit to eat. Ripe fruits are abundant from May to July.



This species is abundant in Peninsular India.

14. **Diospyros hirsuta**, Linn. fil. Suppl., p. 440 (1781).

Thw. Enum. Ceyl. Pl., p. 181, n. 15 (1860). Alph. DC. Prodr. VIII., p. 223, n. 5 (1844). Bedd. Icon. Pl. Ind. Or. 1871. Hiern, Mon. Eben. 163. C. P. 382. Fl. B. Ind. III., 565. Hiern, p. 163-164, includes *D. Moonii*, Thw. and *D. Thwaitesii* Bedd., as varieties of *D. hirsuta*, L., but for reasons given this grouping cannot be maintained.

A small or moderate-sized tree, evergreen, dioecious, monœcious, and polygamous ; bark black with narrow irregular grooves and ridges ; branches pubescent when young, often groups of stiff brown hairs occurring in local areas on young twigs (*cf.* *D. Thwaitesii*).

*Leaves* alternate, 90-200 mm. long, 30-60 mm. wide, ovate-lanceolate, tapering apex, obtuse or acute, tapering base ; young leaves densely pubescent, hairs persisting on under-surface, lateral veins and midrib ; sub-coriaceous, pale green below, venation reticulate ; *petiole* 8-11 mm. long.

Flowers March-October ; ripe fruits March-August.

The polygamous condition is very frequent as a result of the fertility of the pistil in male flowers ; the hermaphrodite flowers occur in any cluster, and consequent on the ripening of the fruit the unisexual flowers become detached leaving only one or two fruiting specimens out of a many-flowered cluster. A single twig or herbarium specimen may therefore appear to be female only.

The monœcious condition has been observed by Thwaites. I have confirmed this in material obtained from Potgulkanda near Ratnapura. The same inflorescence possesses male and female flowers, the former with rudimentary pistil and the latter with barren staminodes. (See. pl. XV., fig. 9).

*The male inflorescence* consists of dense axillary cymes, sometimes short, at other times drawn out to a length of 20 mm. All the flowers are sessile or subsessile, but an opposite pair of small pubescent bracteoles occurs at the base of each flower suggesting a suppressed dichasial cyme.

*Calyx* green, pubescent, irregularly lobed ; segments 4-5, accrescent, acute apex, 36 mm. long.

*Corolla* yellow, with narrow throat, diameter of mature flower 5 mm. ; segments 4-5, overlapping in bud with exposed half externally pubescent, become horizontal when flower mature, acute apex.

*Stamens* 5, epipetalous, alternate with corolla segments ; *anthers* brown, glabrous, apiculate, 2.5 mm. long ; *filaments* white, short ; pollen yellow, smooth, circular.

*Pistil* central rudimentary.

*Female inflorescence* consists of a sessile cluster of flowers in the axil of a leaf, fewer than male, never solitary except by falling away of young flowers ; bracteoles as in male.

*Calyx*, larger than in male ; segments 4-5, covered with long brown unicellular hairs, 10 mm. long, accrescent in bud with feeble intersegmental pouch.

*Corolla* yellow, thick ; segments 5, acute apex.

*Staminodes* 5, epipetalous, alternate with corolla segments ; *anthers* brown, barren, apiculate, glabrous, 2 mm. long ; *filaments* white, glabrous, 0.3 mm. long.

*Pistil* brown, thickly coated with unicellular hairs which persist in ripe fruit (*cf.* *D. Moonii*, *D. Thwaitesii*) ; stigmas 1, sessile ; ovary globose-apiculate, 8-celled (*cf.* *D. Thwaitesii*).

*Fruit* broadly globose-ovoid, apiculate, 30 mm. high, 70 mm. in circumference, hairs detached only with difficulty ; fruiting calyx persistent, enlarged, flattened, thick, margins much reflexed and undulated, segments 15 mm. long.

*Seeds* 1-8, usually 6 per fruit, elliptical-wedge-shaped with beaked micropyle, 20 mm. long, 10 mm. wide, 9 mm. thick ; testa brownish-black, prominently striated transversely ; endosperm copious, horny, ruminate ; embryo white, 10-14 mm. long. (See. pl. XV., fig. 11-12).

*Seedlings* epigeal, cotyledons detached early, epicotyledonary system enhanced developmentally and can be seen by the naked eye in the seed ; *cotyledons* white, long and narrow, measuring when mature 18 mm. in length and 6 mm.

in width ; *hypocotyl* white, stout, glabrous, 60-65 mm. long ; *epicotyledonary* stem yellowish-green, pubescent, 3 mm. long ; *epicotyledonary* leaves form an opposite pair and prior to the dropping of the cotyledons attain a length of 15 mm. though within the confines of the seed ; hairy on under-surface, particularly midrib and margin ; *traces* three per cotyledon, median abortive, laterals splitting considerably ; *epicotyledonary* one per leaf prolonged into root.

*The timber* possesses no black heartwood, and when freshly cut is dirty white in colour turning reddish on exposure ; the colour is due to coloured contents mainly in the wood parenchyma and medullary ray cells ; a change in colour of the walls occurs. (See pl. I., fig. 3.)

The percentage number of fibres varies from 74-83 per cent. and that of the tracheal elements from 0.3 to 1.3 per cent.

The rings of growth are inconspicuous.

In the Peak Wilderness I came across a variety of this species characterized by a flattened circular fruit and stout persistent style. It was abundant along the banks of streams and in damp forests near Eratna, Madola, and Kadawatta.

*Distribution.*—endemic and limited to our wet zone up to 1,500 feet, rather rare but often abundant along the banks of streams and in rocky damp forests.

Katugasella, Potgulkanda, Kukule korale, Galle, Ratnapura, Nawadun korale, Eratna, Kadawatta, Madola.

15. **Diospyros insignis**, Thw. Enum. Ceyl. Pl., p. 180., n. 10 (1860).

Gona Poruwa-mara, Wal-mediriya, S.

Thw. Enum. 180. Hiern, Mon. Eben. 157. C. P. 2,730 (3,477).

Fl. B. Ind. III., 564. Bedd. Ic. Fl. Ind. Or. t. 130 (1871).

A moderate-sized tree, rarely exceeding 200 mm. diameter, with a straight stem unbranched until near the top, evergreen, dioecious and polygamous (monœcious ?) ; bark white or grey, characterized by long shallow irregular

cracks about 10 mm. apart, running vertically through a distance of 100-200 mm.; peels off in large thin flakes exposing brown surface; young twigs thick, green and pubescent; the habit and bark characters are very pronounced.

*Leaves* alternate or sub-opposite, 140-240 mm. long, 40-120 mm. wide, ovate-lanceolate or oblong, acute apex rounded or narrowed at base, glabrous, toughly membranous, pale green beneath; venation conspicuous, midrib and lateral veins project on lower surface, lateral veins connected by parallel transverse veinlets; *petiole* green, cylindrical, glabrous, 15 mm. long, 2.5 mm. diameter.

The polygamous state is very common; the same stages as determined in *D. sylvatica*, *D. Gardneri*, and *D. affinis* have been observed for this species. The hermaphrodite and male flowers occur on the same tree, showing all stages between a central apiculate disc and a pistil with an 8-celled ovary; the hermaphrodite flowers may occur in the same cluster as the male, or in separate clusters, the occurrence being very erratic. (See pl. XIV., fig. 2).

*Male inflorescence* consists of an axillary subsessile cluster, 3-10 flowers similar to those described for *D. hirsuta*; flowers in March on stems 60 mm. diameter. (See pl. XIV., fig. 1).

*Calyx* green, 4 mm. long; segments 4, short, accrescent, ovate, acute apex, nearly glabrous.

*Corolla* yellowish-white, shortly tubular, 10 mm. long, narrow-throated when mature: segments 4, rotate, short, pale and hairy outside.

*Stamens* 14-16-20, epipetalous at base of corolla, single or paired, inner shorter than outer, average length 5 mm., very unequal; *anthers* brown, apiculate, longer than filaments, length 3.5 (outer), 2 mm. (inner); *filaments* white, glabrous or pubescent, length 3 mm. (outer), 0.5 mm. (inner).

*Pistil* apiculate central disc, pubescent, 5 mm. high; crude locular structure seen in transverse section.

The female flowers have not been previously described.

*Female inflorescence* consists of solitary or sessile axillary clusters of 1-6 flowers. (See pl. XIV., fig. 3).

*Calyx* green, pubescent; segments 4, 5 mm. long, accrescent in flower with feebly recurved margin and small inter-segmental pouch.

*Corolla* yellowish-white, tubular, 10 mm. long, throat narrow; segments 4, outside covered with silky hairs, tend to become recurved in mature flower.

*Staminodes* 4-5, epipetalous; *anthers* barren, apiculate; *filaments* white, glabrous or nearly so.

*Pistil* green, feebly pubescent; stigmas 4, green, ovary 8-celled; after fertilization becomes enveloped in rapidly growing calyx and only stigma can be seen for some time.

*Fruit* green, glabrous except near apex, subglobose with cruciform depressed apex, with calyx like an acorn in appearance, 40 mm. high, 75 mm. circumference; fruiting calyx considerably enlarged, segments woody, 20 mm. long, with apices strongly pointed and projecting outwards and downwards, margin recurved and coated with long velvety hairs; in mature fruit the calyx is strongly tetrahedral in outline, and the basal part forms a cup over 20 mm. deep in which fruit rests (*cf.* *D. Ebenum*). (See pl. XIV., fig. 4).

*Seeds* 4-7-8 per fruit, oval-wedge shape; 28 mm. long, 11 mm. wide, 7 mm. thick; testa smooth, deep brown, transverse striæ not prominent; endosperm copious, horny, ruminant.

I have often suspected the monœcious condition in this species, but the occurrence of pure male and female flowers on the same tree has yet to be definitely proved. On some male trees I have found young flowers possessing a fertile pistil and a staminal whorl of five members, but whether these anthers were barren in consequence of being young or otherwise I could not satisfy myself.

There appears to be a variety of this species in the Ratnapura District, characterized by smaller leaves and fruits, darker bark, and less feebly cornered fruiting calyx.

*Seedlings* epigeal, cotyledons detached early, epicotyledonary system slightly enhanced developmentally. *Cotyledons* white, 10-13 mm. long, 4-6 mm. wide; *hypocotyl* white, glabrous, very short type similar to *D. oocarpa* and suggestive of hypogeal tendency; seeds are never raised above the ground and the hypocotyl is never strongly arched; 15-20 mm. long. Epicotyledonary system is long and narrow and easily frees itself from the confines of the decaying cotyledons and endosperm, and at the time of detachment of cotyledons measures 10 mm. in length and 1-5 mm. diameter.

The *epicotyledonary* stem when 65 mm. long bears 3-5 small leaves about 1 mm. in length and disposed at irregular distances; at the apex there are two larger leaves, opposite, but at different levels; these are glabrous, thin, bullate, and measure 50 mm. in length.

*Traces* 3 per cotyledon, xylem splits at different levels of hypocotyl and primary root. One trace per epicotyledonary leaf, but on account of splitting of cotyledonary xylem difficult to follow.

*Timber*.—Trimen (p. 100) describes the heartwood as being small and black with pale streaks, and states that it is one of those called "kalumediriya"—the Sinhalese name for calamander. At Ratnapura I found this belief still strong and it was only after much persuasion that trees on private grounds were felled for my inspection. Every specimen which I have seen is white when freshly cut, turning a dirty colour on exposure. Only on one occasion was the black heartwood present and this was very small and rotten. (See pl. III., fig. 3).

The gum-resin is present in very small quantities; the soft parenchymatous tissues are very abundant, and the timber must therefore be regarded as of an inferior quality. The tree provides excellent straight posts and is therefore frequently felled. The rings of growth are very inconspicuous, sometimes they occur as broad dark bands alternating with narrower and lighter zones. These are sometimes so closely

arranged that a radius of 10 mm. may contain 12 rings, whereas in some specimens very large areas may be free from any such differentiations. Perhaps such rings of growth are the expression of special periods of activity, independent of seasonal forces?

*Distribution.*—This species is common in the moist low-country up to 2,500 feet; Kandy, Polgahawela, Ambagamuwa, Avisawella, Kuruwiti korale, Hewesse, Kalutara, Kottawa, Potgulkanda, Katugasella, Udugama, Yagarilla, Penjaval, Hinidun, Eratna, Kadawatta, Ambalawa, Pindeniya, Pitigalla.

Also in Anamalai Hills, South India.

16. **Diospyros oppositifolia**, Thw. Enum. Ceyl. Pl., p. 181., n. 11 (1860).

Kalumediriya, Kadumberiya, S.

Thw. Enum. 181. Hiern, Mon. Eben. 157. C. P. 3,011.

Fl. B. Ind. III., 565. Bedd. Ic. F. Ind. Or., t. 131.

A moderate-sized or large tree, evergreen, monœcious only; trunk erect, not buttressed, bark black, never deeply grooved but fissures somewhat similar to *D. insignis*. *Leaves* opposite or sub-opposite, 50–130 mm. long, 35–75 mm. wide, oval, shortly acuminate or obtuse apex, rounded at base, pubescent when young, glabrous when old, coriaceous; venation reticulate, pellucid, lateral veins and parallel transverse connecting veins conspicuous when fresh; *petiole* dark, glabrous, 2–5 mm. long; phyllotaxy, texture and form somewhat similar to *D. Melanoxylon*.

The male and female flowers are always found together on the same tree. Usually a solitary female flower terminates the young shoot, and in the axils of the lower leaves clusters of male flowers arise. In one specimen male and female flowers were in separate but opposite clusters of 9 and 2 flowers respectively on a young twig; in another case there were two residual flowers of a cluster, one of which was a true male, the other showing a ripening pistil; in other cases the female flowers may occur solitary in the axil of the

lower leaves. There was very little evidence of a constant or annual floral periodicity in the trees examined. It is interesting to note that though this endemic species is monœcious, only the male flowers have been previously described. The sex, female flowers, and fruits are here described from material I obtained in the forest in 1901.

*Male inflorescence* consists of a sessile or subsessile cluster of 1-9 flowers in the axil of leaves or on old twigs. The male flowers never terminate a young shoot and usually occupy the part below the female flower or flowers; they are rarely mixed with female flowers in the same cluster. Each flower is subtended by a small caducous green bracteole. The flowers are yellow, fragrant when fresh and measure 10 mm. when unopened. (See pl. VI., figs. 3, 4).

*Calyx* brown or green, diameter 16 mm.; segments 4, acuminate apex, sub-glabrous, 4 mm. long.

*Corolla* yellow, tubular, swollen at base, when open measures 15 mm. long; segments 4, rotate, with tapering acute apex, half of outer surface covered with brown hairs, 5 mm. long, 2.5 mm. wide at base.

*Stamens* 8 (4+4), epipetalous, usually in pairs but filaments not united, inner shorter than outer; pairs usually alternate with corolla segments, though liable to variation; *anthers* yellow, apiculate, glabrous apex, hairy at back, 2.5 mm. long; *filaments* white, covered with long unicellular hairs, 1 mm. long, sometimes absent or very short for inner stamen.

*Pistil* absent or as a central pubescent apiculate structure.

*The female flowers* and fruits have not been previously described. Flowers usually solitary terminating young shoot, subsessile or on peduncle measuring 8-15 mm. long, 2 mm. diameter; peduncle greenish, finely pubescent, and may or may not bear bracteoles; yellow, fragrant. (See pl. VI., fig. 1).

*Calyx* green, outside finely pubescent, 9 mm. total length, diameter 4 mm.; segments 4, rarely 3, deeply cut, tapering acute apex, thick, 6 mm. long.



*Corolla* yellow, outside covered with short white hairs, 16 mm. long when unopened, diameter of open flower at top 20 mm.; segments 4, rarely 3, rotate, tapering acute apex; 10 mm. long.

*Staminodes* 4, epipetalous, alternate with corolla segments; in one case there were eight separate staminodes each typical in form and having barren anthers; *anthers* barren, brown, tapering apex but not apiculate, 2 mm. long; *filaments* white, glabrous, 1.5 mm. long.

*Pistil* with 4 stigmas, yellowish-watery appearance, thin and undulating; style stout, 4 mm. long, 1.5 mm. diameter; ovary small, greenish, nearly glabrous, 8-celled, the loculi of adjacent pairs becoming grouped opposite the middle of calyx segments.

*Fruit* solitary, terminates young shoot, ovoid-attenuate, 30 mm. long, 12 mm. diameter, green, glabrous. Some fruits have a broad base and taper quickly towards apex; others are narrow at base and strongly attenuate at apex; fruiting calyx woody, enlarged, forming deep cup for fruit, total length 18 mm., cup 18 mm. diameter. (See pl. VI., fig. 2)..

*Seeds* 2-5 per fruit, wedge-shaped having convex surface in contact with carpellary wall, tapering strongly towards both ends; 28 mm. long, 10 mm. wide; testa brown, smooth; endosperm copious, horny, equable.

*Embryo* white.

*Timber*.—Regarding the wood from this species, Trimen states (Vol. III., p. 101) that according to Thwaites the timber resembles true calamander, but that the tree requires more careful examination and is almost unknown. The Sinhalese name is the same as that applied to calamander. My experience does not confirm this. The timber when freshly felled is white or dirty white in colour, with a hollow decayed centre. Young trees 75 mm. (3 inches) diameter are invariably hollow in the centre, and large trees measuring 480 mm. diameter possess only a narrow peripheral band of dirty white living wood, the central and median portions

being quite rotten. On exposure the timber changes to a darker colour with irregular streaks of black, often giving a pattern to the transverse section similar to what has been noted in *D. ovalifolia*. (See pl. II., 8).

The discolouration is often due to a change in the colour of the cell walls only. The relative scarcity of gum-resin and the abundance of parenchymatous cells, particularly of the medullary ray, necessarily make the timber very inferior in quality.

The rings of growth are inconspicuous.

*Distribution*.—This is our rarest species of *Diospyros* and up to the present has only been found on the upper part of the Haycock mountain, or Hinidumkanda, between 1,500–2,000 feet. The climate there prevailing is unique, the upper part being, more often than not, capped with mist, and arborescent vegetation is of a stunted xerophytic type. There are not more than 40 or 50 trees of this species and these occur mixed with trees of calamander. The character of the erect trunk with its black bark is very similar to that of calamander trees, and the fact of their being so freely mixed with trees of calamander is probably the source of the error regarding the value of the timber. This species should grow well on the steep rocky hill sides in the Peak Wilderness, where the rainfall is high.

17. ***Diospyros Thwaitesii***, Bedd. Ic. Pl., Ind. Or. 27 (1874).  
Kadumberiya, S.

Hiern, Mon. Eben. 164. C. P. 3394. Fl. B. Ind. III., 566.  
Bedd. Ic. Pl. Ind. Or. t. 135

A small or medium-sized tree, 300–1,500 mm. in circumference, and attaining a height of 18 metres (60 feet), evergreen, dioecious, monoecious, and polygamous; bark black, slightly rougher than *D. hirsuta*, with longitudinal fissures 2 mm. deep and 4 mm. wide; bark 3 mm. thick in tree 110 mm. diameter, young twigs covered with brown hairs becoming green and glabrous. *Leaves* alternate, 80–120 mm. long, 20–40 mm. wide, ovate-lanceolate, tapering towards apex;

apex acute or obtuse, tapering base, pubescent on both surfaces when young, especially midrib, glabrous and shining when old, thin, venation reticulate, meshes wide, midrib prominent beneath, lateral veins inconspicuous; petiole green, finely pubescent, slightly grooved above, 8 mm. long, 2 mm. diameter. Flowers in March to June; fruits March-October.

The monœcious condition was seen at Palaketi, near Udugama. The male clusters and female flowers occur irregularly on the same or different twigs. I fully satisfied myself that the 5 staminodes in the fruiting flowers were barren, this being the species in which the monœcious condition was first noticed. The polygamous condition established by the occurrence of male and hermaphrodite flowers on the same tree is very frequent. Pure male and female trees occur in the same district, and it occurred to me that perhaps the trees now bearing unisexual flowers may at another time of the year produce hermaphrodite flowers. The sex appears to be very unstable. (See pl. XVI., fig. 3-4).

At Palaketi there is a variety of this species characterized by broader and coriaceous leaves, in which the lateral veins and midrib are conspicuous on the upper surface, and measure 40-120 mm. long and 30-50 mm. broad.

*The male inflorescence* consists of a sessile axillary cluster of 4-15 flowers; each flower is subtended by a small bract, 2 mm. long, acuminate apex, green and glabrous above, covered with red hairs below. (See pl. XVI., fig. 1).

*Calyx* green, hairy, 3 mm. diameter, 4 mm. long in open flower; segments 5, accrescent, with tapering apex, not undulate in flower.

*Corolla* yellowish-white, 8 mm. long, 8 mm. diameter of open flower at top, throat widely open and covered above and below with silky hairs; segments 5, rotate, tapering apex, broad base, half of flower surfaces covered with brown hairs.

*Stamens* variable but usually 5 epipetalous pairs alternating with corolla segments, attached by separate or united

filaments; in other cases 10–18 arranged in pairs and singles without fixed orientation; *anthers* unequal, reddish-brown, apiculate, apex well pointed with long unicellular hairs to disseminate the pollen, average length 3 mm.; *filaments* yellowish-white, glabrous, 1.5 mm. long; *pollen* yellow, even outline, circular, feebly granular contents.

*Pistil* rudimentary disc, apiculate, densely pubescent.

*The female flowers* occur solitary, or as a cyme in the axil of foliage leaves; when solitary the flower is surrounded with an involucre of small bracteoles suggesting 3–7-flowered inflorescences; bracteoles with hairy midrib, acute apex, 9 mm. long, 5 mm. wide. (See pl. XVI., fig. 2).

*Calyx* brown, pubescent, campanulate in flower measuring 10 mm. in depth; segments 5, tapering apex, slightly reflexed margin, undulating intersegmental groove, pubescent.

*Corolla* yellowish-white, 10 mm. diameter, corolla throat wide; segments 5, rotate, acute apex, half of under surface densely pubescent.

*Staminodes* 5, epipetalous, alternate with corolla segments, filaments attached near apex of throat; *anthers* barren, brown, apiculate with silky brown attenuate hairs as in male; *filaments* white, very short. *Pistil* with 2 stigmas, yellowish-white, style absent; ovary globose-apiculate covered with dense coating of brown hairs, 4-celled, one ovule in each cell.

*Fruit* globose-apiculate covered with long brown hairs when young, but tending to become glabrous when old, 30 mm. long, 60 mm. circumference; fruiting calyx not much enlarged. (See pl. XVI., fig. 5).

*Seeds* 2 per fruit, oval-elliptical in shape, with strongly beaked micropyle; 18 mm. long, 10 mm. wide, 8 mm. thick; testa brown, transversely striated; endosperm abundant, ruminate. (See pl. XVI., fig. 6).

*Seedlings* epigeal; *cotyledons* drop, but usually only after persisting as a white lamina, void of palisade tissue, for one or two days. During this time, they never develop any chlorophyll though the enhanced epicotyledonary leaves

are of a deep green colour ; cotyledons white, 20 mm. long, 12 mm. wide ; *hypocotyl* white, thinner than *D. Moonii*, 85-90 mm. long ; *epicotyledonary stem* pubescent, a trifle longer than *D. Moonii*, 6-10 mm. long ; epicotyledonary leaves form an opposite pair, cordate, tapering acute apex, midrib hairy beneath, 25 mm. long, 20 mm. broad. Three *traces* per cotyledon, xylem of median trace abortive and liable to be overlooked in sections not horizontal ; one trace per epicotyledonary leaf, continued into the root but in old seedlings absent from the apical part of the root.

*Timber*.—The sapwood when freshly cut presents a dirty appearance while the heartwood is light red. There is no real black heartwood, only small black traces here and there. The coloured materials in the various elements are small in quantity ; fibres are abundant and medullary rays poor, hence an even-grained timber results. Rings of growth sometimes conspicuous, the light narrow rings measuring 0.2-1.2 mm. radial diameter and being distanced 2-8 mm. radially from one another. (See pl. II., Fig. 9).

*Distribution*.—This species is found in the moist low-country forests, rather rarely ; it grows well on moist, rocky, or sandy soils, and under close canopy usually measures 4.5-6 metres (15-20 feet) to first branch, and has a total height of 6-9 metres (20-30 feet), the average circumference being about 320 mm. The largest trees occur at Hiniduma at an elevation of 800 feet, measurements already quoted. Ratnapura, Hiniduma, Sinha Raja forest, Hewess, Palaketi.

18. **Diospyros Moonii**, Thw. Enum. Ceyl. Pl., p. 182., n. 16 (1860) Kadumberiya, Kaluwella, S.

Thw. Enum. 182, C. P. 2,833. Hiern, Mon. Eben. 164. Fl. B. Ind. III., 566. Bedd. Ic. Fl. Ind. Or. t. 138.

A moderate-sized tree, evergreen, dioecious ; small trees have a relatively smooth black stem, but larger specimens are deeply grooved and buttressed at the base ; average height from 7.6-10.6 metres mm. (25-30 feet), maximum 13.8 metres (45 feet), breast height circumference 760 mm. (2½ feet) ;

young branches black and smooth ; on old twigs the bark is rather scaly and pinkish-red turning to brown when freshly cut.

*Leaves* alternate, 190-350 mm. long, 70 mm. wide, ovate-lanceolate, short tapering acute apex, rounded base, pubescent when young, glabrous or nearly so when old, thick and leathery ; venation reticulate, meshes wide, not pellucid, lateral veins rather conspicuous below ; midrib prominent below, channelled above ; *petiole* green, cylindrical, 15 mm. long, 5 mm. diameter. Flowers October, ripe fruits March to October.

*Male inflorescence* consists of a sessile cluster of 1-8 flowers on old twigs ; bracteole subtending each flower green, pubescent, tapering acuminate apex, broad base early caducous 3 mm. long, 3 mm. wide at base. (See pl. XVI., fig. 7).

*Calyx* brown, hairy ; segments 5, 4 mm. long, acute apex. *Corolla* yellow and 5-lobed ; *stamens* five ; *pistil* rudimentary. Fresh specimens of open flowers not seen.

*Female flowers* solitary or as a sessile inflorescence ; a ring of 2-5 bracts at base of solitary flower, 8 mm. long, 4 mm. wide. (See pl. XIV., fig. 6).

Fresh material of young flowers not seen.

*Calyx* green, pubescent, cupuliform ; segments 5, bluntly apiculate, recurved margin, slight intersegmental groove.

*Corolla* yellowish-white and 5-lobed ; staminodes present.

*Pistil* globose, pubescent. *Fruit* solitary or in groups 2-4, sessile or subsessile, globose with depressed apex, 90-130 mm. circumference, 30-50 mm. long, green, slightly hairy, long hairs easily detached, 10-celled ; fruiting calyx persistent to fruit, enlarged, segments measuring 15 mm. in length, flattened, densely pubescent. (See pl. XIV., fig. 7).

*Seeds* 6-10 per fruit, elliptical-ovate, or rather flattened ; testa brown, transversely striated, outer layer peels off readily ; endosperm strongly ruminate ; 23 mm. long, 15 mm. wide, 6 mm. thick ; embryo white, 15 mm. long. (See pl. XIV., fig. 9-10).

*Seedlings* epigeal; cotyledons not readily detached but never function as assimilatory organs and exist as white or shrivelled leaves for a few days; by the time the cotyledons are dead the enhanced epicotyledonary leaves are deep green and well developed (*cf.* *D. Thwaitesii*).

*Cotyledons* white, 13 mm. long; *hypocotyl* white, glabrous, 90 mm. long; *epicotyledonary* stem greenish, hairy, 3 mm. long; epicotyledonary leaves form an opposite pair, ovate, rounded apex, rounded or tapering base, glabrous, 50 mm. long, 25 mm. broad; *traces* 3 per cotyledon, xylem of median trace weak, xylem of lateral cotyledonary traces much split; one trace per epicotyledonary leaf, weak and continued into root.

*Timber*.—A typical red wood with occasional small black strands; black heartwood absent or small; the elements are feebly lignified, even the fibres; vessels have rather large transverse dimensions. The colouring substances are not very abundant. The timber is much inferior to ebony but superior to the yellow and white woods already described. It is rarely felled even where very abundant, and most natives disregard it entirely as a source of durable timber.

*Distribution*.—Moist lowcountry, rather rare, Kalutara, Hewessa, Penijaval Forests, Kadawatte, Hinidumkanda, near Galle. It grows well in poor sandy or rocky soils providing there is plenty of water; in some districts it can only be found alongside the streams with roots occasionally submerged; often accompanies *D. Embryopteris* and *D. quæsita* in moist low-country.

Endemic.

The habit of *D. Moonii* is very different from that of *D. hirsuta* or *D. Thwaitesii*, and in this respect greatly resembles *D. Embryopteris*; the fleshy leaves resemble those of *D. acuta*; the flat relatively thin fruiting calyx and the large globose fruits are widely different from anything met with in *D. hirsuta* or *D. Thwaitesii*. *D. Thwaitesii* resembles *D. hirsuta* in many features, but can always be distinguished from it in virtue of its 4-celled ovary, larger number of stamens, thinner and smaller leaves.

The three species have therefore been described separately.

19. **Diospyros affinis**, Thw. Enum. Ceyl. Pl., p. 179, n. 6 (1860).

Kaluwella (Viriniya), Semel Panachai, S.

Fl. B. Ind. III., 566. C. P. 2,924. Hiern, Mon. Eben. 169. Bedd. Ic. Fl. Ind. Or. t. 127 (1871).

A moderate-sized or large tree, evergreen, dioecious and polygamous; young twigs green and slightly pubescent, older twigs brown to black and shiny; bark of young branches thick, alternate longitudinal grey and black layers, 10 mm. wide and 40–80 mm. long. In old trees the grey layer becomes the fissure and the dark layer the ridge. The fissures becomes very large and characteristic of the bark. The bark peels away in irregular thick patches.

*Leaves* alternate, 35–90 mm. long, 13–30 mm. wide, oval or oblong, tapering towards apex, apex obtuse, narrowed at base, glabrous, coriaceous; venation reticulate, meshes wide, not strongly pellucid, net veins rather prominent beneath; *petiole* flattened above, 10 mm. long, 1–5 mm. diameter.

Flowers in June–August; ripe fruits June–October.

The polygamous condition is very frequent. At Viriniya in June, 1902, I obtained abundance of ripe fruit from polygamous trees of this species. The fruits were a trifle smaller than those obtained from true female trees. The hermaphrodite flowers only differ from the male flowers on the same tree in having larger calyces and a fertile pistil, the number and nature of stamens being the same. The hermaphrodite flower when occurring alone on a male cyme usually occupies the position of the median and oldest flower (*cf.* *D. oppositifolia*). In other cases the majority of the flowers of a particular cyme are hermaphrodite. (See pl. X., fig. 5).

I have also found the polygamous condition on a tree in the Peradeniya Gardens in March, 1903; this particular tree had not been in flower for at least the last three years.



*The male inflorescence* consists of cymose cluster of 3-7 flowers in axil of caducous bract or foliage leaf. The peduncle is green, hairy, 10 mm. long, 2 mm. diameter. The pedicels vary in length from 2-4 mm., diameter 2 mm.; bracts green, hairy, caducous, 12 mm. long; bracteoles of lateral flowers 9 mm. in length, long tapering apices, green and glabrous, gradually decreasing in size from below upwards, those subtending the ultimate pedicels being very small.

*Calyx* green, tubular, glabrous, 7 mm. long, 2.5 mm. diameter; segments 4, variable length, apex acute.

*Corolla* yellowish-white, length 12 mm., average diameter 3 mm.; segments 4, hairy outside, acute apex, broad base, 4 mm. long.

*Stamens* 6-9-16, forming central hypogynous ring, in pairs or single; *anthers* reddish-brown, glabrous, slightly apiculate, 3-4 mm. long; *filaments* white, glabrous, 1 mm. long; *pollen* circular, yellow.

*Pistil* rudimentary, represented by a bunch of hairs.

*Female flowers* solitary on stout peduncles. Peduncles green, nearly glabrous, 5-10 mm. long, 2.5 mm. diameter; pair at right angles to antero-posterior axis near base of flower suggesting a cyme with abortive lateral flowers (*cf.* *D. Gardneri*); bracteoles caducous, very small. (See pl. X., fig. 1).

*Calyx* green, hairy inside, sub-glabrate outside, 13 mm. long; segments 4, tapering apex, 10 mm. long, undulating margin, conspicuous intersegmental pouch.

*Corolla* yellowish-white, tubular; segments 4, short.

*Staminodes* 6-8, epipetalous at base of corolla or part hypogynous, glabrous, barren anthers.

*Pistil* green; styles two, each bifid at apex; ovary usually 6-celled, occasionally 8-celled, when latter the loculi are opposite and alternate to calyx lobes, when former four loculi alternate with calyx lobes, the other two taking up any position.

*Fruit* green or yellow when ripe, globose, slightly apiculate, becomes glabrous, 30 mm. diameter, 25 mm. long; fruiting calyx enlarged, 30 mm. diameter, rather flattened with segments glabrous, black, apices in contact with carpelary wall, margins reflexed, intersegmental pouch large.

*Seeds* usually 4, ovate, wedge shaped, 18 mm. long, 11 mm. wide, 7 mm. thick; testa deep brown; endosperm copious and ruminate.

*Seedlings* epigeal, cotyledons detached early, epicotyledonary system well developed before detachment of cotyledons occurs; *cotyledons* white, 11 mm. long, ovate, apex obtuse; *hypocotyl* white, 7 cm. long; *epicotyledonary* stem reddish, pubescent, 4 mm. long; *epicotyledonary* leaves form an opposite pair, ovate, tapering towards base, apex tapering, obtuse; venation reticulate; 35 mm. long, 20 mm. wide; *traces* 3 per cotyledon, fairly equal in strength, xylem of lateral strands split to varying degrees; one epicotyledonary trace per leaf, continued into hypocotyl and root.

*Timber*.—The coloured heartwood is usually small but occasionally very good; one tree measuring 24.4 metres high (80 feet) and nearly 2 metres circumference, (6½ feet) possessed a small black heartwood only 100 mm. (4 inches) diameter; in some specimens much smaller than the foregoing the heartwood was large, streaked brown, and probably sold as “bastard” ebony; such samples are often equal to our best woods from an ornamental point of view (*cf.* *D. oocarpa*). (See pl. I., fig. 4).

The colouring matter is very abundant even in the sapwood; the fibres are very high in percentage number, and possess narrow lumina.

Rings of growth are inconspicuous.

*Distribution*.—dry and intermediate zones, rather rare; between Uma-oya and Bilihul-oya on the lower Badulla road from Kandy; Viriniya, near Bibile; Bintenna, Kantalai, Kalugalla, Vavuniya.

Also in Tinnevely, S. India.

20. **Diospyros crumenata**, Thw. Enum. Ceyl. Pl., p. 179, n. 5 (1860). Fl. B. Ind. III., 567. C. P. 2,438. Hiern, Mon. Eben, 169. Bedd. Ic. Pl. Ind. Or. Part VII., p. 26, t. 126 (1871).

A large evergreen tree, dioecious; bark thick, black, rather scaly; trunk erect, twigs glabrous.

*Leaves* alternate, 50–120 mm. long, 25–50 mm. wide, oval-oblong, abruptly acuminate apex, rounded or narrowed at base, glabrous and shining, coriaceous, pellucid venation, net veins rather prominent; *petiole* canaliculate above, 6–10 mm. long. Flowers March–August; ripe fruits January–October.

*Male inflorescence* consists of a pedicellate spreading cyme of 3–7 flowers. (See pl. VIII., fig. 1.)

*Flowers* yellow, 15 mm. long, throat 4 mm. diameter, top of open flower 11 mm. diameter. Peduncle 3–10 mm. long, green, hairy; ultimate pedicels 1–4 mm. long.

*Calyx* green, cupuliform, 5–10 mm. long, glabrous inside; segments 4, short or obscure.

*Corolla* yellow, tubular, 14 mm. long; segments 4, short, rounded apices, broad and recurved in open flower.

*Stamens* 8–14, hypogynous, 4–6 mm. long; *anthers* brown or yellow, attenuate, glabrous, 4–5 mm. long; *filaments* white, glabrous, 1 mm. long, sometimes absent; *pollen* yellow, circular. (See pl. VIII., fig. 2.)

*Pistil* absent or rudimentary.

*Female flowers* solitary, in axil of foliage leaves and usually limited to the lower part of young shoot; approximately spherical in bud, measuring 9 mm. diameter. Peduncle 5–10 mm. long, 2–5 mm. diameter; two or more small caducous bracteoles occur on the peduncle, the first two forming an opposite pair at right angles to antero-posterior axis (cf. *D. affinis*). (See pl. VIII., fig. 3.)

*Calyx* green, under surface hairy; segments 4, accrescent in flower, acute apex; margin becomes reflexed, and deep intersegmental pouches are formed after the flower has opened.

*Corolla* yellowish-white, 15 mm. high, tubular, throat somewhat constricted, basal part swollen; segments 4, rotate, rounded apices, undulated margins, tomentose on both sides.

*Staminodes* 8, epipetalous, opposite and alternate with corolla segments, 3 mm. long; *anthers* barren, glabrous, not apiculate but apex shows signs of bifurcation; *filaments* white and glabrous. (See pl. VIII., fig. 4.)

*Pistil* greenish-yellow, pubescent; stigmas 4, fleshy, short; ovary 8-celled.

*Fruit* green, 25–40 mm. diameter, 40 mm. long, depressed-globose, apiculate, glabrous or nearly so; 8-celled, loculi opposite and alternate with calyx segments. (See pl. VIII., fig. 5.)

Fruiting calyx enlarged, woody, flattened, intersegmental areas are straightened and outline of calyx is tetrahedral (cf. *D. insignis*).

*Seeds* 1–8 in each fruit, flattened and elliptical, 45 mm. long, 20 mm. wide, 11 mm. thick; testa umber-brown, shining; endosperm copious, ruminate; embryo white, 24 mm. long.

*Seedlings* epigeal, cotyledons detached early, epicotyledonary axis well developed; *cotyledons* white, feebly petiolate, 16 mm. long, 7 mm. wide; *hypocotyl* white and cylindrical, changing to black and four cornered, 110 mm. long, 3 mm. diameter; *epicotyledonary* stem red, hairy, 15 mm. long; traces 3 per cotyledon, much splitting of xylem in collet area; one epicotyledonary trace per leaf—continued into root, rarely shows splitting of xylem.

*Timber*.—This is of medium quality and belongs to the red kind. The red colour intensifies from without inwards and local black strands occur here and there. The coloured heartwood is not usually large; some specimens, however, yield a large black and brown streaked heartwood of considerable beauty and value. The sapwood is much less durable than the heartwood, in consequence of the wide

lumined tracheal and parenchymatous elements there existing. The heartwood contains a fair percentage of fibres of narrow lumen. Trees of this species are certainly worth a little attention, judging from many excellent specimens which I have seen at Ambalawa, near Gampola.

*Distribution.*—Endemic and rare, limited to moist region, 1,500–4,000 feet; Deltota, Uduwella, below Haputale, Hantane, Gangaruwa, Kalugalla, Ambalawa. *See fig. 78.*

## KEYS TO THE CEYLON SPECIES OF DIOSPYROS.

### General Characters.

The following key is based on the general characters of the leaves, fruits, and stems, and may be found useful as a substitute for that given by Trimen. With the help of this key and the illustrations of every species showing flowers, fruits, seeds, timber, and leaves there ought to be no difficulty in identifying species of Diospyros in the forests of Ceylon.

#### ENDOSPERM EQUABLE.

*Leaves large, 110 to 300 mm. long.*

Fruit flattened or ovoid-globose,  
covered with glandular hairs ... *1. D. Embryopteris.*  
Fruit attenuate, feebly pubescent... *2. D. acuta.*

*Leaves 50–200 mm. long.*

Leaves opposite ... *3. D. oppositifolia.*

Leaves alternate.

Leaves thin, not coriaceous,  
feebly pellucid.

Fruit depressed-globose,  
stem spiny ... *4. D. montana.*

Fruit strongly attenuate,  
stem smooth ... *5. D. attenuata.*

Leaves coriaceous, strongly  
pellucid venation.

*Seeds flat.*

Fruits depressed-globose, leaves  
bullate and pellucid ... *9. D. Gardneri.*

Fruit globose-ovoid, nervation  
not pellucid ... *11. D. quæsita.*

*Seeds wedge-shaped.*

Nervation closely reticulate,  
fruit-calyx thin and flat ... *4. D. Toposia.*

Nervation wider mesh, fruit-  
calyx woody and cup-  
shaped ... *5. D. Ebenum.*

*Leaves small, 50-120 mm. long.*

Leaves and fruits covered with very  
long hairs ... *6. D. pruriens.*

Leaves and fruits glabrous.

Veins and calyx segments in-  
conspicuous, seeds deeply  
grooved ... *10. D. oocarpa.*

Veins and calyx segments con-  
spicuous, seeds superficially  
striated ... *1. D. ovalifolia.*

## ENDOSPERM RUMINATE.

Male corolla urceolate, seeds small  
and rounded ... *12. D. sylvatica.*

Male corolla tubular, seeds wedge-  
shaped or flat.

*Leaves large, 100-300 mm. long.*

Fleshy, veins not prominent,  
bark thick ... *18. D. Moonii.*

Coriaceous, veins prominent,  
bark thin and scaly ... *15. D. insignis.*

*Leaves 35-130 mm. long.*

Mature fruit hairy ...*4*. **D. hirsuta.**

Mature fruit glabrous or nearly so.

\* Fruit-calyx much enlarged and woody.

† Leaves oblong-oval, 40-90 mm. long, feebly pellucid venation ...*6*. **D. affinis.**

†† Leaves with acuminate apex, 50-130 mm. long, pellucid venation ...*10*. **D. crumenata.**

\*\* Fruit-calyx not much enlarged nor woody.

† Fruit globose, 35 mm. high, leaves broadly oval ...*3*. **D. Melanoxylon.**

†† Fruit broadly ovoid, 25 mm. high, leaves narrowly lanceolate ...*7*. **D. Thwaitesii.**

### **Seedling and Fruit Characters.**

The following key has been constructed mainly from characters of the seeds and seedlings. In several instances the number and behaviour of cotyledonary traces would have been of service, but as such characters cannot be used outside the laboratory those of the fruit have been included as being of more practical importance in determining the identity of species in the forest.

#### **ENDOSPERM EQUABLE.**

*Cotyledons persistent.*

Seeds flat, thin (2 mm.) ...*9*. **D. Gardneri.**

Seeds wedge-shaped.

Fruit-calyx large, woody, segments acute, first epicotyledonary leaf small, only 2 mm. long *5*. **D. Ebenum.**

Fruit-calyx small, thin, segments rounded, first epicotyl leaf average size, 20 mm. long, **D. montana.**

*Cotyledons dropping.*

Hypocotyls short (10-50 mm.), epicotyledonary stems long (40-70 mm.).

Seeds irregular in shape, deeply grooved, hypocotyl 10-30 mm., fruit—calyx segments undistinguishable. ... **D. oocarpa.**

Seeds oval - elliptical or wedge-shaped, hypocotyl 40-50 mm. long ... **D. Toposia.**

Hypocotyl long (30-100 mm.), epicotyledonary stems short (3-40 mm.).

Seedlings densely pubescent **D. pruriens.**

Seedling glabrous or nearly so.

\* Seeds rounded and short (9 mm.), testa superficially striated ... **D. ovalifolia.**

\*\* Seeds large and flat, 30 mm. long.

Testa transversely striated, epicotyledonary leaves opposite ... **D. quæsitæ.**

Testa not striated, epicotyledonary leaves sub-opposite ... **D. Embryopteris.**

\*\*\* Seeds semi-lunar or wedge-shaped.



- Seeds acuminate at micro-  
 pyle, fruit-calyx large  
 and convolute ...**8. D. acuta.**
- Seeds not acuminate, fruit-  
 calyx small and thin ...**7. D. attenuata.**
- Fruit-calyx forms deep cup  
 (18 mm.) ...**16. D. oppositifolia.**

# ENDOSPERM RUMINATE.

## *Cotyledons persistent.*

- Seeds short (14 mm.), globular ...**12. D. sylvatica.**

## *Cotyledons dropping.*

- Hypocotyl short (15 to 20 mm.), epi-  
 cotyledonary stem long, with leaf  
 rudiments (65 mm.) ...**15. D. insignis.**

- Hypocotyls long (60-110 mm.),  
 epicotyledonary stem short (3-15  
 mm.).

## *Fruits small, 27 × 23 mm.*

- Fruit wall with dense layer of  
 brown hairs, fruit 8-celled ...**14. D. hirsuta.**
- Fruit wall when old nearly  
 glabrous, fruit 4-celled ...**17. D. Thwaitesii.**

## *Fruit large, 36 × 33 mm.*

### *Seeds flat and thin.*

- Testa deeply striated, fruit-  
 calyx small, thin ...**18. D. Moonii.**
- Fruit-calyx large, woody,  
 strongly recurved ...**20. D. crumenata.**

### *Seeds wedge-shaped or semi-lunar.*

- Fruits globular, fruit-calyx  
 large, thick, and undulate ...**13. D. Melanoxydon.**
- Fruits apiculate or flattened  
 at top, fruit-calyx thin  
 and small ...**19. D. affinis.**

In conclusion, I take this opportunity of expressing my thanks to Mr. J. C. Willis, for first suggesting the genus *Diospyros* to me, and for the help received during the progress of this work while enjoying the tenure of my appointment as Scientific Assistant. I have also to thank Messrs. A. F. Broun, F. Lewis, H. P. C. Armitage, A. M. Walker, A. M. Fontyne, and other officers of the Ceylon Forest Department for the time they have spent conducting me through their districts and for the many specimens received from them. For similar favours I must also express my gratitude to Messrs. W. P. Hiern; J. H. Maiden, Director of the Botanic Gardens, Sydney; C. A. Barber, Government Botanist, Madras; Major Prain, Superintendent, Royal Botanic Gardens, Calcutta; to Mr. J. Wilson, China; Mr. W. C. Curtis, Penang; and to the Conservator of Forests of the Andaman Islands.

The drawings have been made from fresh material, mainly by Mudaliyar William de Alwis, late Draughtsman at Peradeniya, to whom my best thanks are due. Plate V. was kindly photographed by Mr. H. F. Macmillan, Curator, Peradeniya, to whom I am grateful for this and many other favours in connection with supplies and propagation of seedlings.

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#### DESCRIPTION OF PLATES I-XX.

*Plate I.*—Sections of the timber of (1) *D. pruriens*, (2) *D. hirsuta*, (3) *D. Moonii*, (4) *D. affinis*, (5) *D. Melanoxylon*, and (6) *D. ovalifolia*.

The relative sizes of the different trees may be calculated from the measure photographed on Plate V. Obviously, the timber of most of the species here described may be obtained in various sizes, but those on the same plate are selected with a view to illustrating the relative sizes of mature trees of the respective species.

*Plate II.*—Transverse sections of the timber of (7) *D. sylvatica*, (8) *D. oppositifolia*, and (9) *D. Thwaitesii*.

Figure 8 shows the characteristic hollow decaying protoxylem area and the streaked nature of the remaining wood in *D. oppositifolia*. The rings of growth in *D. sylvatica* are perhaps clearer than in any other Diospyros species.

*Plate III.*—Transverse sections of the timber of (10) *D. attenuata* (12) *D. Toposia*, (13) *D. insignis*, with characteristic bark, and (11) oblique section and log of *D. acuta* showing bark characteristic of most Diospyros species.

*Plate IV.*—Transverse sections of (14) *D. crumenata*, (15) *D. oocarpa*, and (16) *D. Ebenum*.

The section of *D. oocarpa* is unusually large and is used to show the large amount of streaked ebony of good quality which is frequently found in this species.

Plate V.—Longitudinal section of (17) *D. quæsitæ* showing streaked heartwood of varying width, transverse section of (18) *D. Gardneri*, longitudinal and oblique sections of (19) *D. Montana*, and (20) *D. Embryopteris*. an/m

Plate VI.—Nat. size. (1-4), *D. oppositifolia* ; (1) female flower terminating young twig ; (2) mature fruit and fruiting calyx ; (3) and (4) male inflorescence and flowers from woody twig ; (5-9) *D. quæsitæ* ; (5) female flowers, young and mature ; (6) seed showing transverse striæ on testa and young seedling stage ; (7) male inflorescences ; (8) fruit in longitudinal section (reduced  $\frac{1}{2}$ ) ; (9) longitudinal section of seed showing embryo *in situ*.

Plate VII.—Nat. size. (1-7), *D. oocarpa* ; (1) male inflorescences ; (2) section through male flower, showing position of stamens ; (3) mature male flower showing calyx with insignificant segments ; (4) female flower ; (5) fruit showing insignificant straight rimmed calyx ; (6) seed ; (7) leaf. (8-14), *D. acuta* ; (8) male inflorescence ; (9) corolla of male flower ; (10) female inflorescence ; (11) solitary female flower ; (12) corolla of female flower ; (13) fruit with calyx ; (14) pistil from mature flower.

Plate VIII.—Nat. size, except (2) and (4).

1-5, *D. crumenata* ; (1) male inflorescence ; (2) section of male flower enlarged to show position of stamens ; from drawings in the herbarium ; (3) solitary female flower ; (4) dissected corolla of female flower showing position of staminodes (enlarged) ; from herbarium drawing ; (5) fruit and recurved fruiting calyx ; (6-9) *D. Melanoxydon* ; (6) female inflorescences ; (7) fruits ; (8) male inflorescences ; (9) male flower.

Plate IX.—Nat. size. *D. Embryopteris*. 1, 2, 3, 4, stages in the development of the female inflorescence showing positions of bracts (for description see Part 1, p. 72) ; (5) mature female inflorescence ; (6) fruit covered with reddish-brown glandular and unicellular hairs ; 7, 8, 9, and 10 stages in the development of male inflorescence ; described in Part 1, p. 73-74 ; (11) mature male inflorescence ; 12 section through male flower showing position of stamens.

Plate X.—Nat. size, except 4 and 10. 1-6, *D. affinis* ; (1) mature female flower ; (2) fruit showing insignificant calyx ; (3) male inflorescences showing positions of detached flowers ; (4) section through male flower showing position of stamens and rudimentary pistil enlarged ; from herbarium drawing ; (5) polygamous inflorescence, median female, and lateral male flowers ; (6) fruit from polygamous tree ; 7-10, *D. Toposia* ; (7) young and (8) mature male inflorescences ; (9) female inflorescence ; (10) fruit, young,  $\frac{1}{2}$  size of mature specimens.

*Plate XI.*—Nat. size. 1-9, *D. sylvatica* ; (1) young male (2) mature male inflorescences ; (3) corolla of male flower dissected to show position of stamens ; (4) polygamous twig bearing upper cluster of male flowers and fruit below ; (5) and (6) sections through flowers from polygamous tree showing development of pistil ; (7) seed showing external rumination ; (8) female inflorescences ; (9) fruit from female tree. 10-15, *D. attenuata* ; (10) male inflorescence ; (11) separate male flower ; (12) seed ; (13) mature fruit showing insignificant calyx ; (14) solitary female flower ; (15) leaf.

*Plate XII.* *D. Gardneri*. Nat. size, except 2 and 10 ; (1) group of hermaphrodite flowers from polygamous tree ; (2)  $\times \frac{1}{2}$  section of hermaphrodite flower showing pistil and stamens ; (3) male flower ; (4) section of male flower ; (5) male inflorescence ; (6) male flowers and fruit on same twig from polygamous tree ; (7) flower from true male tree ; (8) section of male flower showing stamens ; (9) corolla of male flower dissected to show position of 8 pairs of epipetalous stamens ; (10) ring of stamens (enlarged) to show groups of various sizes, from herbarium drawing ; (11) solitary female flower ; (12) section through female flower showing staminodes and pistil ; (13) corolla of female flower dissected to show the position of eight epipetalous staminodes ; (14) longitudinal section of seed showing equable endosperm and embryo *in situ*.

*Plate XIII.*—Nat. size.

*D. Ebenum* 1-8. (1) Male flowers ; (2) female cymose inflorescence ; (3) solitary female flowers ; (4) polygamous clusters (a) female (b) male flowers ; (5) monœcious group (a) female (b) male flowers ; (6) group of stamens showing fusion and unequal length ; (7) fruit and recurved calyx ; (8) transverse section of young fruit.

*D. pruriens* (9-12). (9) Male flowers and leaves ; (10) staminal whorl magnified ; (11) fruit with long hairs ; (12) seed with embryo.

*Plate XIV.*—Nat. size.

*D. insignis* (1-5). (1) Male flowers ; (2) polygamous flowers (a) female flower ; (b) same flower separated from cluster ; (3) female flowers in bud ; (4) fruit with calyx ; (5) L. S. of seed with embryo and showing ruminate endosperm.

*D. Moonii* (6-10). (6) Young fruits ; (7) male flowers in bud ; (8) fruit with calyx ; (9) seed showing transverse striæ ; (10) longitudinal section of seed to show embryo and ruminate endosperm.

*Plate XV.*—Nat. size except 4 and 5 which were taken from drawings in the herbarium.

*D. ovalifolia* (1-5). (1) Male inflorescence ; (2) female flowers, fruit, and leaf ; (3) seed showing irregular striæ ; (4) pistil *in situ*,

corolla, and staminodes removed ; (5) pistil figured from above to show crenate bifid stigma.

*D. hirsuta* (6-12). (6) Male inflorescence ; (7) female inflorescence ; (8) polygamous group (a) female flower ; (b) male flowers ; (9) monœcious group (a) female ; (b) male ; (10) fruit and calyx ; (11) seeds exposed after carpellary wall removed ; (12) longitudinal section of seed showing embryo.

*Plate XVI.—Nat. size.*

*D. Thwaitesii* (1-6). (1) Male flowers ; (2) female flowers ; (3) polygamous group (a) female (b) male flowers ; (4) monœcious state (a) female (b) male cluster ; (5) fruit and calyx ; (6) young seedling.

*D. montana* (7-10). (7) fruits and leaf ; (8) section through fruit showing seeds and embryos *in situ* ; (9) male flower ; (10) female inflorescence.

*Plate XVII.—Nat. size.*

*D. insignis* (1-3). (1) Germinated seed representing a stage of the seedling when the cotyledons are detached, but the epicotyledonary system not liberated ; (2) a later stage showing the hypocotyl less than one cm. in length and young epicotyledonary stem ; (3) an old seedling showing short hypocotyl, long epicotyledonary stem with rudimentary leaves along its length and a pair of large leaves at the apex.

*D. Toposia*. (4) Seedling showing median length for hypocotyl and long epicotyledonary stem without leaf rudiments.

*D. sylvatica* (5-6). (5) young seedling ; (6) mature seedling with long hypocotyl and a pair of persistent foliaceous cotyledons. Note the absence of epicotyledonary leaves.

The first pair of leaves in the seedlings of these three species are approximately the same height above the ground.

*Plate XVIII.—Nat. size except 6 to 8.*

*D. pruriens* (1-5). (1) Seed showing embryo ; (2) young seedling ; (3) seedling with white cotyledons attached at cotyledonary node ; (4) stage showing the shrivelled cotyledons after a few hours' exposure and the enhanced epicotyledonary leaves ; (5) mature seedling showing cotyledons detached and a scar at the cotyledonary node, an epicotyledonary stem about one cm. in length, and the first pair of epicotyledonary leaves as an opposite pair similar to the cotyledons of *D. sylvatica*.

*Embryos* (6-8). (6) *D. crumenata* ( $\times 2$ ) ; (7) *D. Embryopteris* ( $\times 2$ ) ; (8) *D. Ebum* ( $\times 2$ ) ; (9) seedling of *D. Embryopteris* showing the pale cotyledons prior to being detached and just exposed by removal of the testa and endosperm ; note the long epicotyledonary hairy stem between cotyledons. (cf. fig 6, pl. XVII.)

*Plate XIX.*—(All  $4 \times D$ ).

*Sclerotic cells* (1-4). (1) From cortex of a twig 0.9 mm. diameter ; (2) from twig 2 mm. diameter ; (3) from branch 70 mm. diameter ; (4) from branch 78 mm. diameter.

*Hairs* (5-10). (5) Origin of unicellular hairs from upper surface of calyx, *D. Ebenum* ; (6) pedicellate multicellular gland, from upper surface of calyx, *D. Ebenum* ; (7 and 8) irregular unicellular hairs from leaf bud *D. Embryopteris* ; (9 and 10) multicellular glands usually on long pedicels, from carpellary wall of fruits of *D. Embryopteris*.

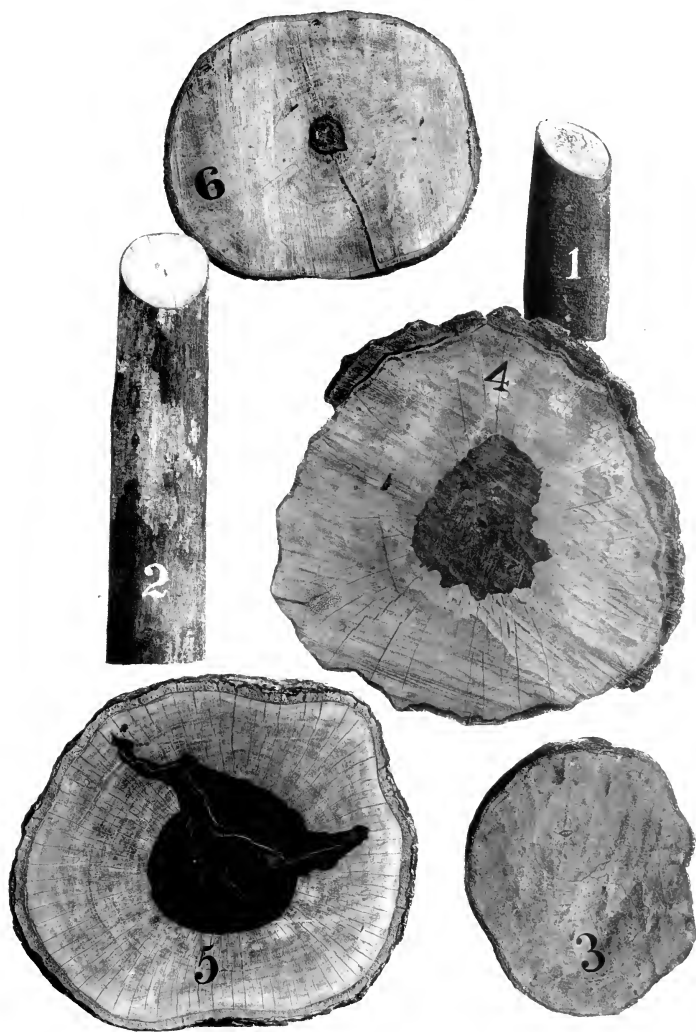
*Plate XX.*

*D. Ebenum* (1-6). (1) Transverse section of xylem,  $D \times 4$  ; (2) transverse section of twig 2 mm. diameter showing origin of phellogen from subepidermal layer ; (3) section, diagramatic, of old xylem with lumina filled with coloured material ; (4) rods of black carbon-like material liberated from the cells after treatment with strong sulphuric acid ; (5 and 6), sections of the xylem showing the appearance of the deposits in the early stages ; transverse and longitudinal.

*Correction.*

In Cooke's Flora of the Bombay Presidency, Vol. II., Pt. 1, received since the above was completed, *D. crumenata* is given as common in the forests between Gairsoppa and Dodmune Ghâts. It is therefore not endemic in Ceylon, as stated on p. 199. 67.





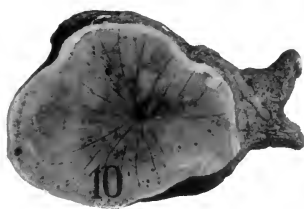
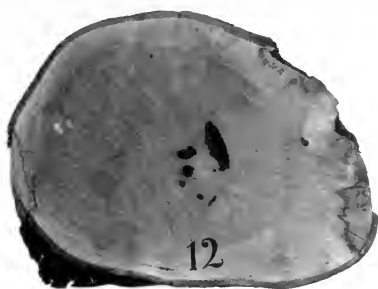
D. PRURIENS (1), D. HIRSUTA (2), D. MOONII (3), D. AFFINIS (4)  
D. MELANOXYLON (5), D. OVALIFOLIA (6)





D. SYLVATICA (7), D. OPPOSITIFOLIA (8), D. THWAITESII (9)



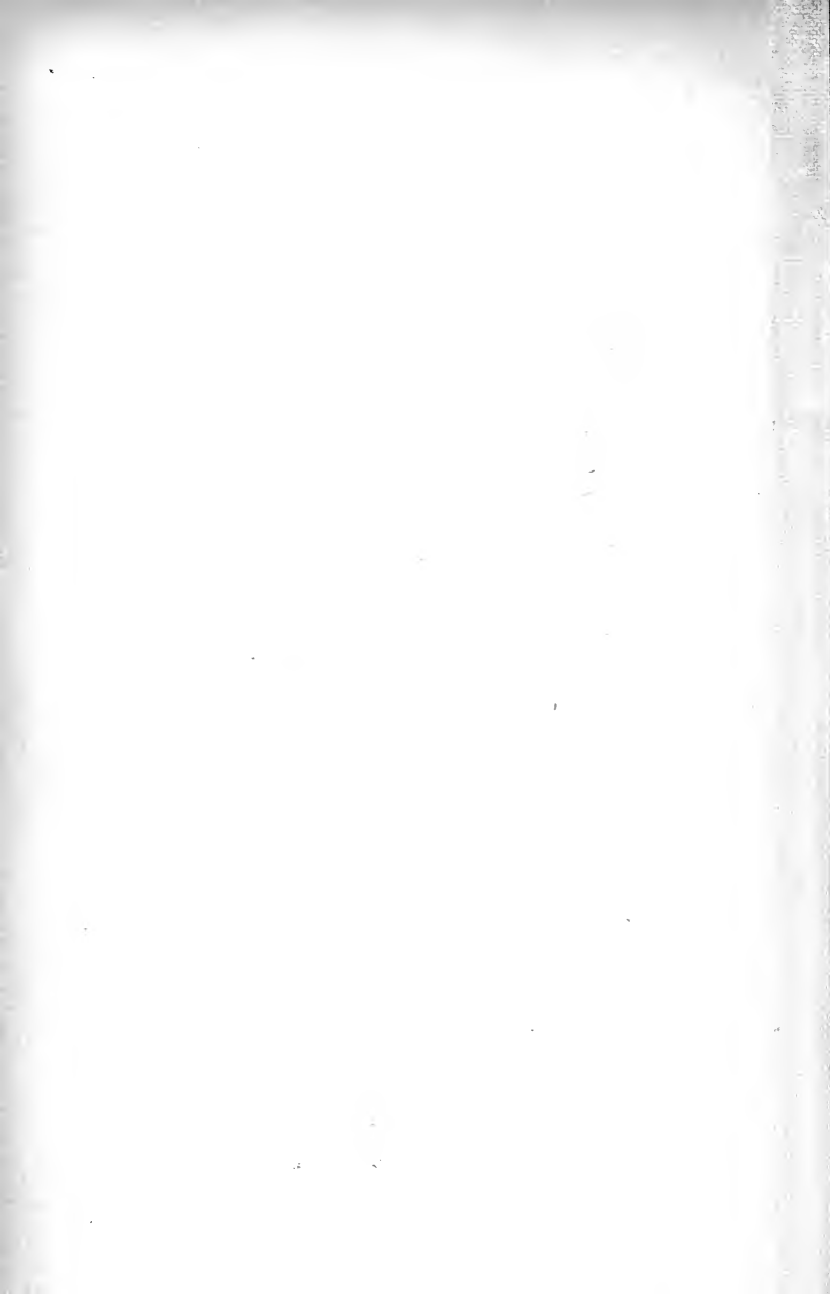


D. ATTENUATA (10), D. ACUTA (11), D. TOPOSIA (12), D. INSIGNIS (13)

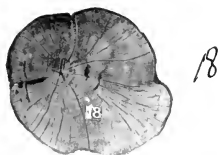




D. CRUMENATA (14). D. OOCARPA (15). D. EBENUM (16)

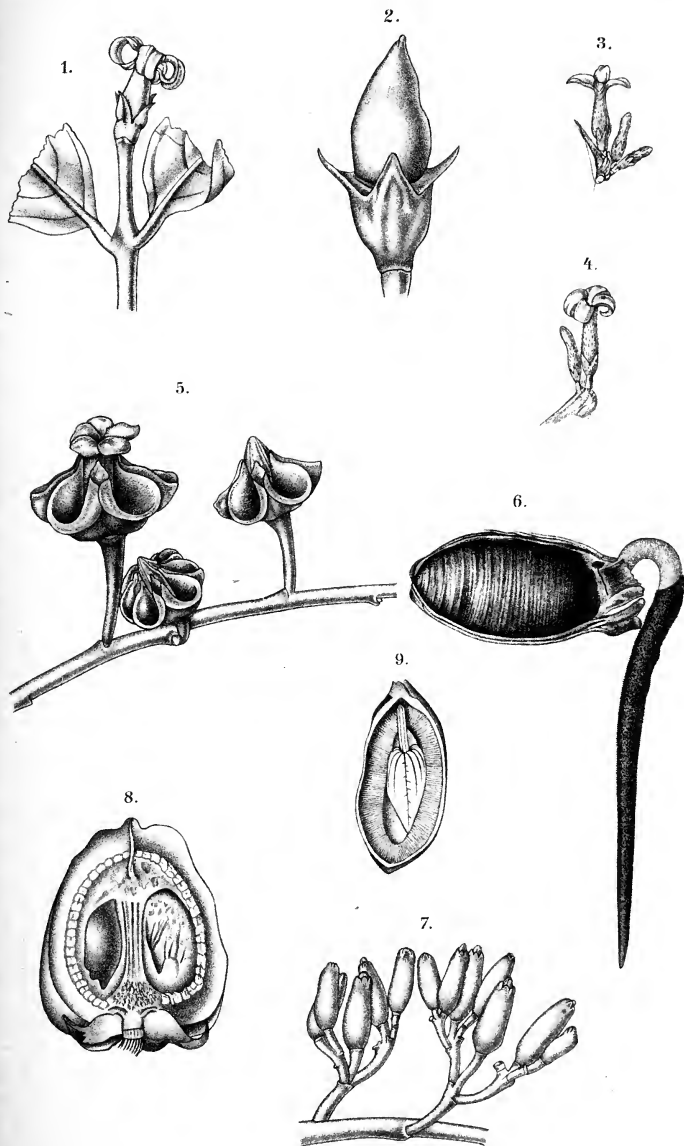




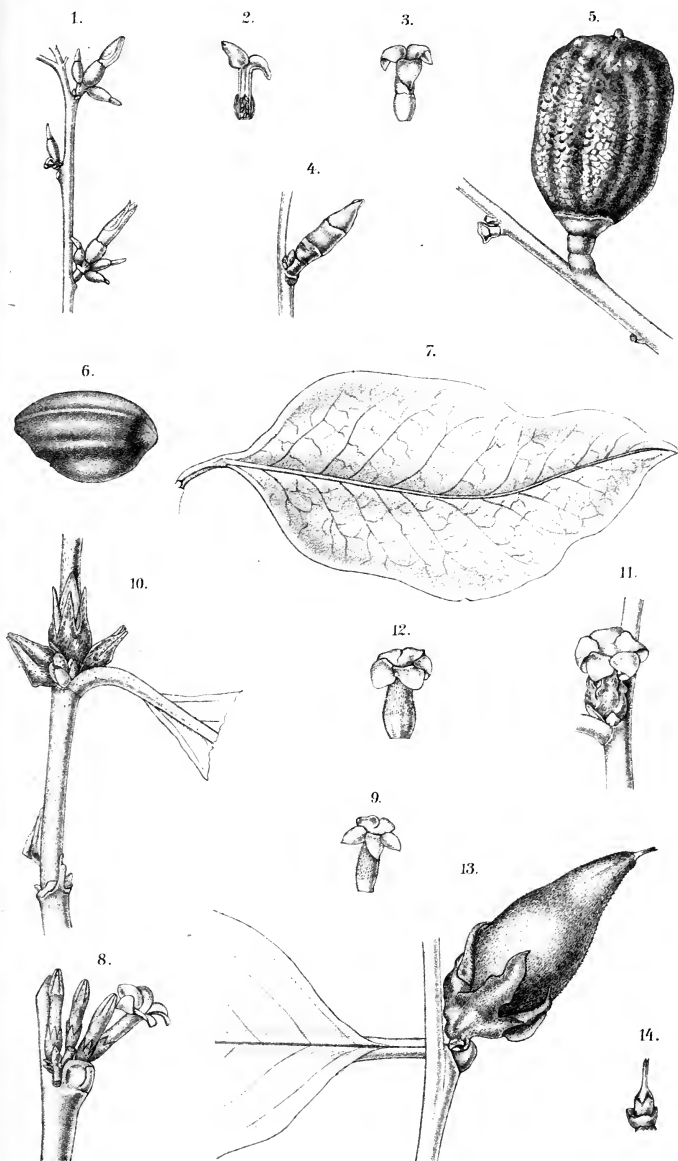


D. QUAESITA (17), D. GARDNERI (18), D. MONTANA (19)  
D. EMBRYOPTERIS (20)





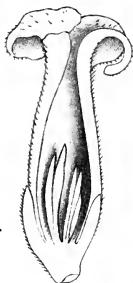




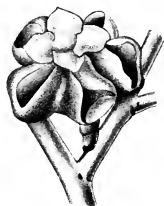




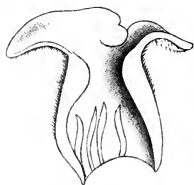
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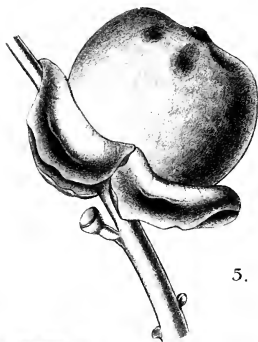
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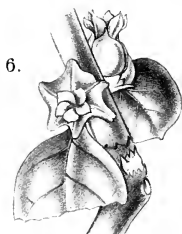
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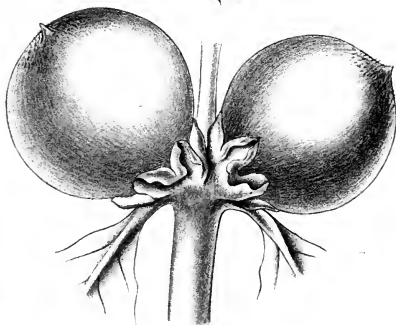
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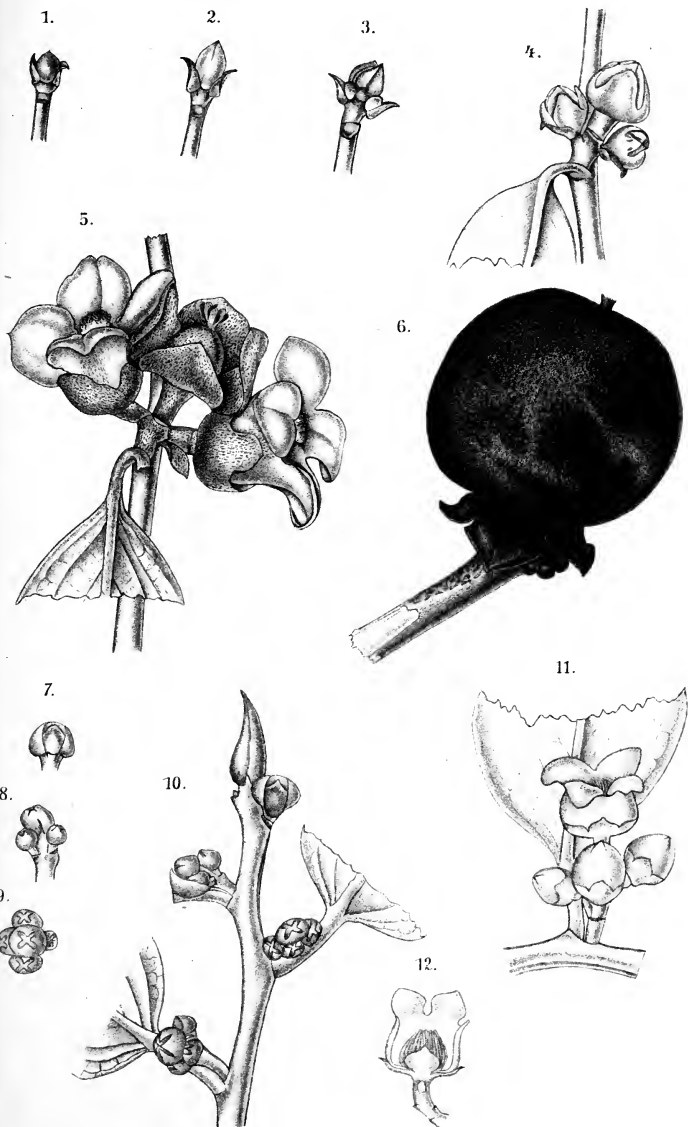
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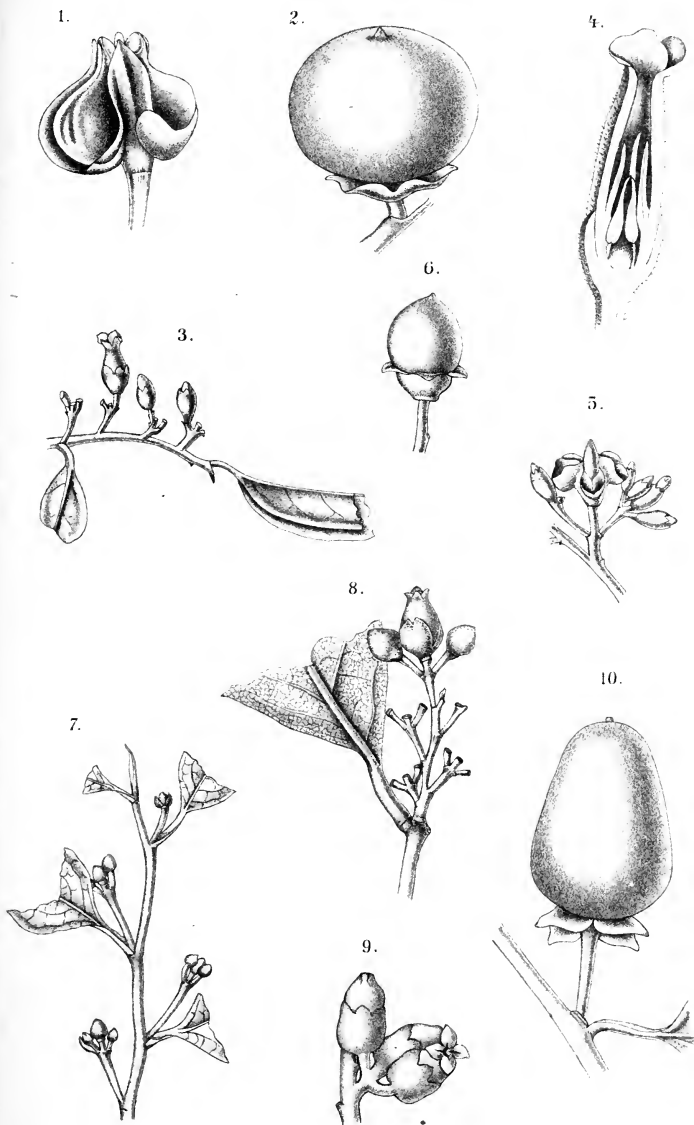
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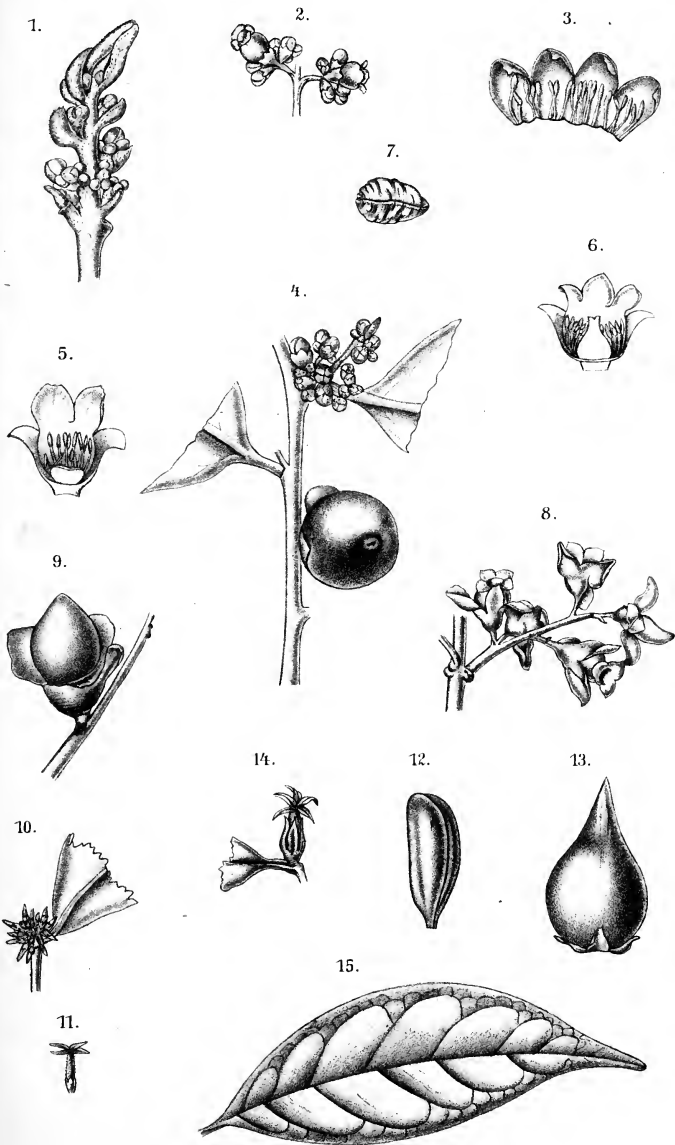


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D. AFFINIS (1-6), D. TOPOSIA (7-10).



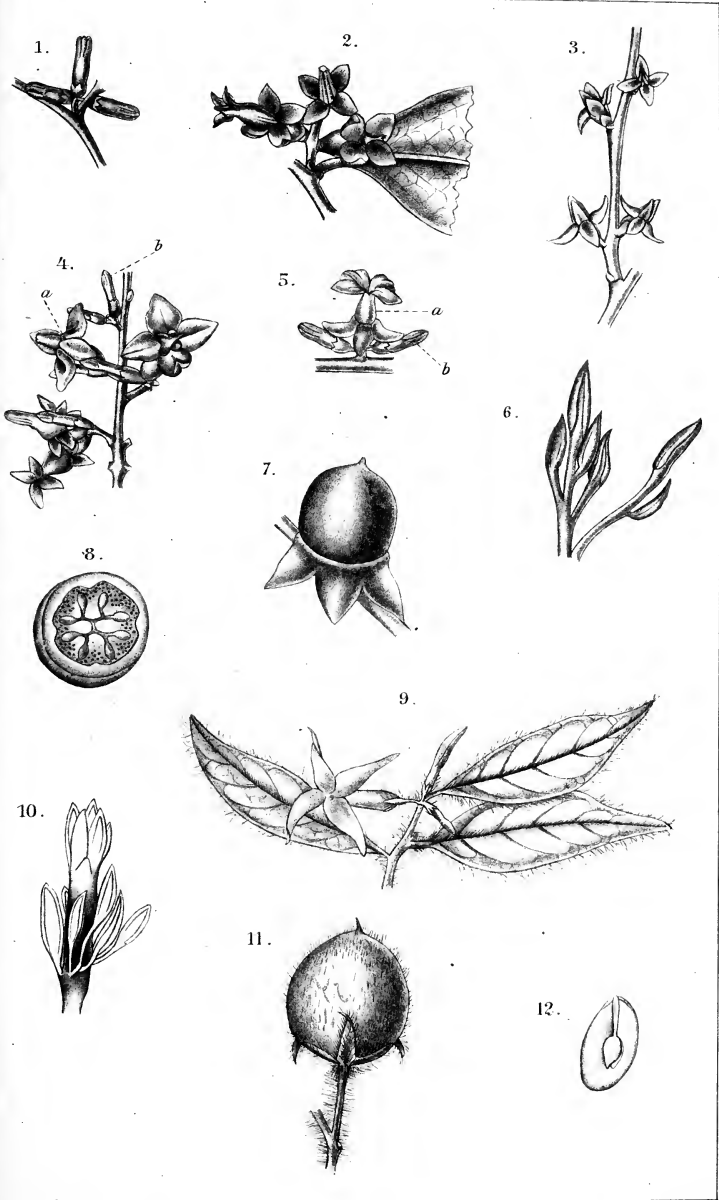






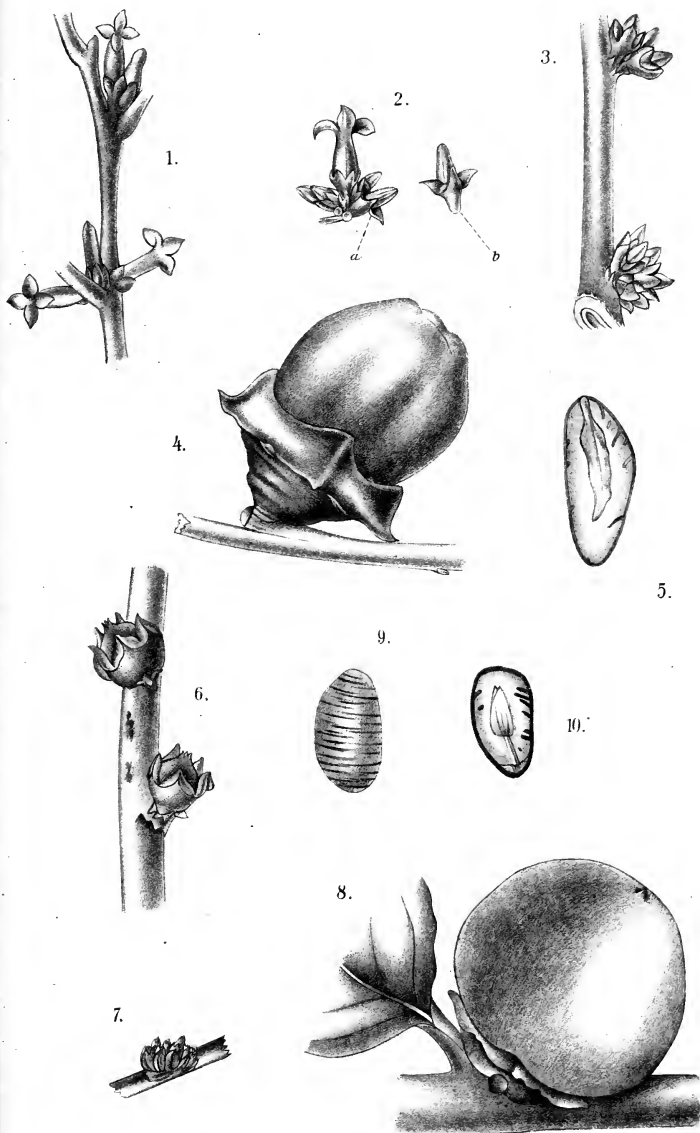




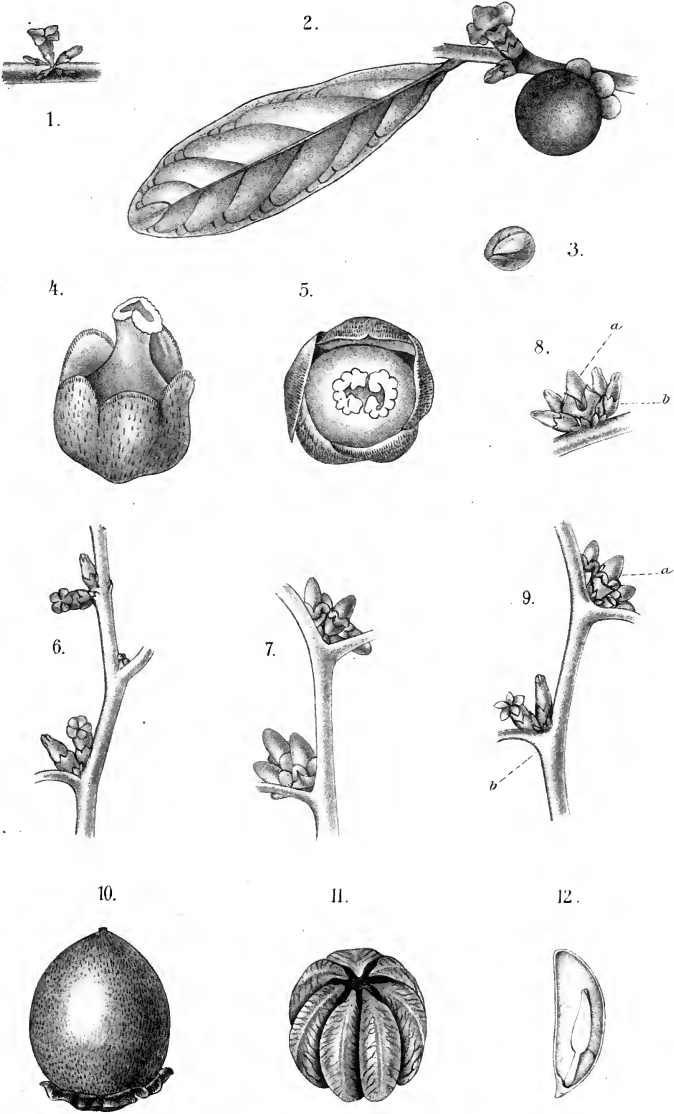


D. EBENUM. (1-8), D. PRURIENS (9-12).

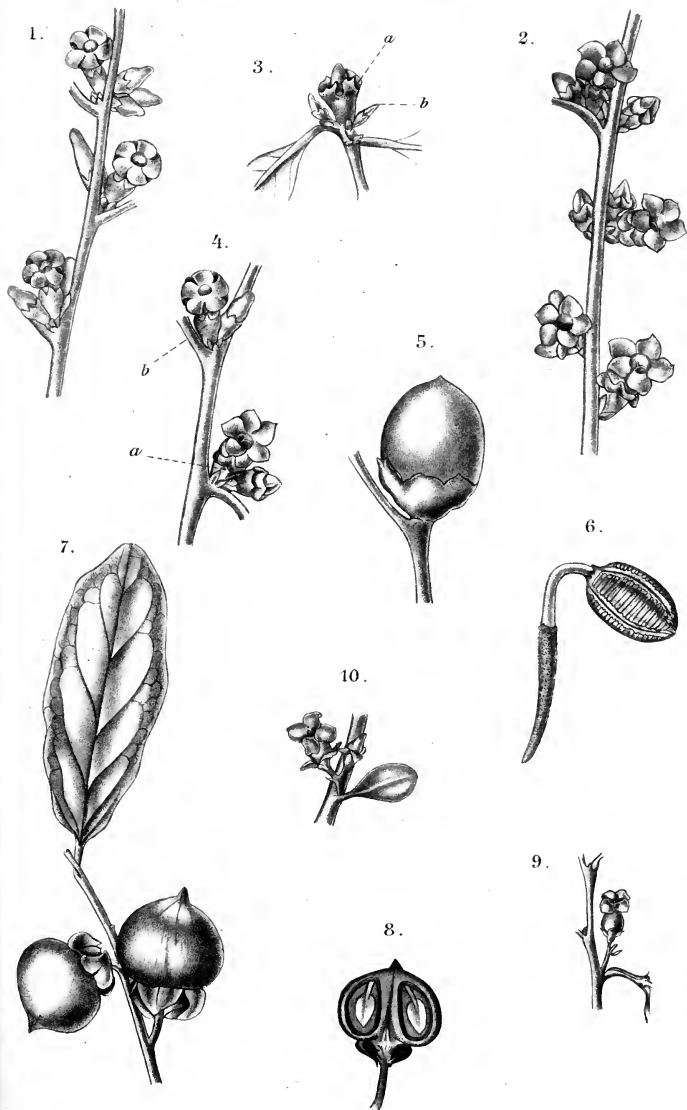






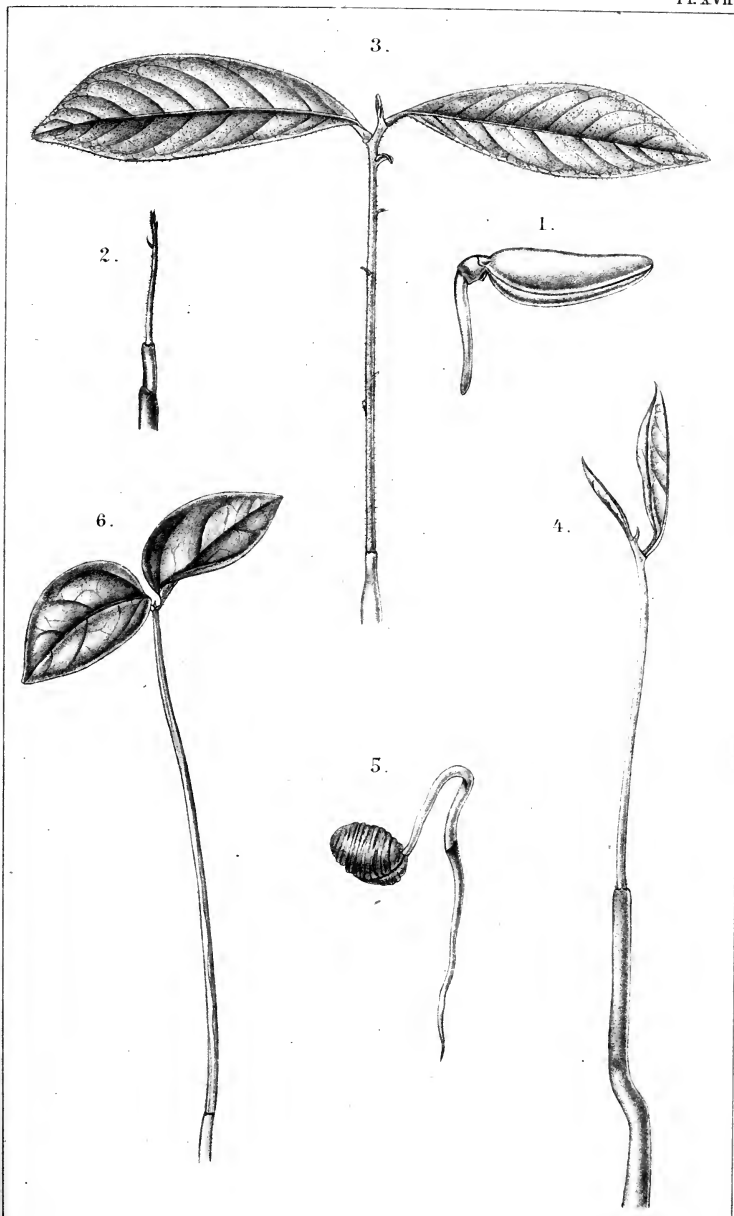




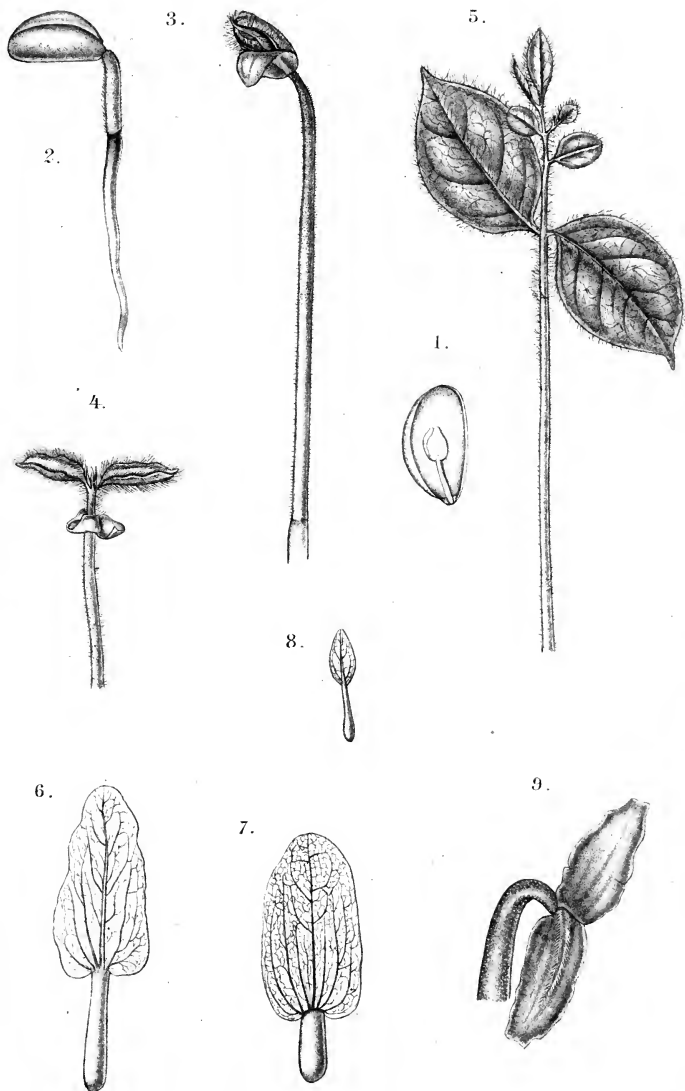


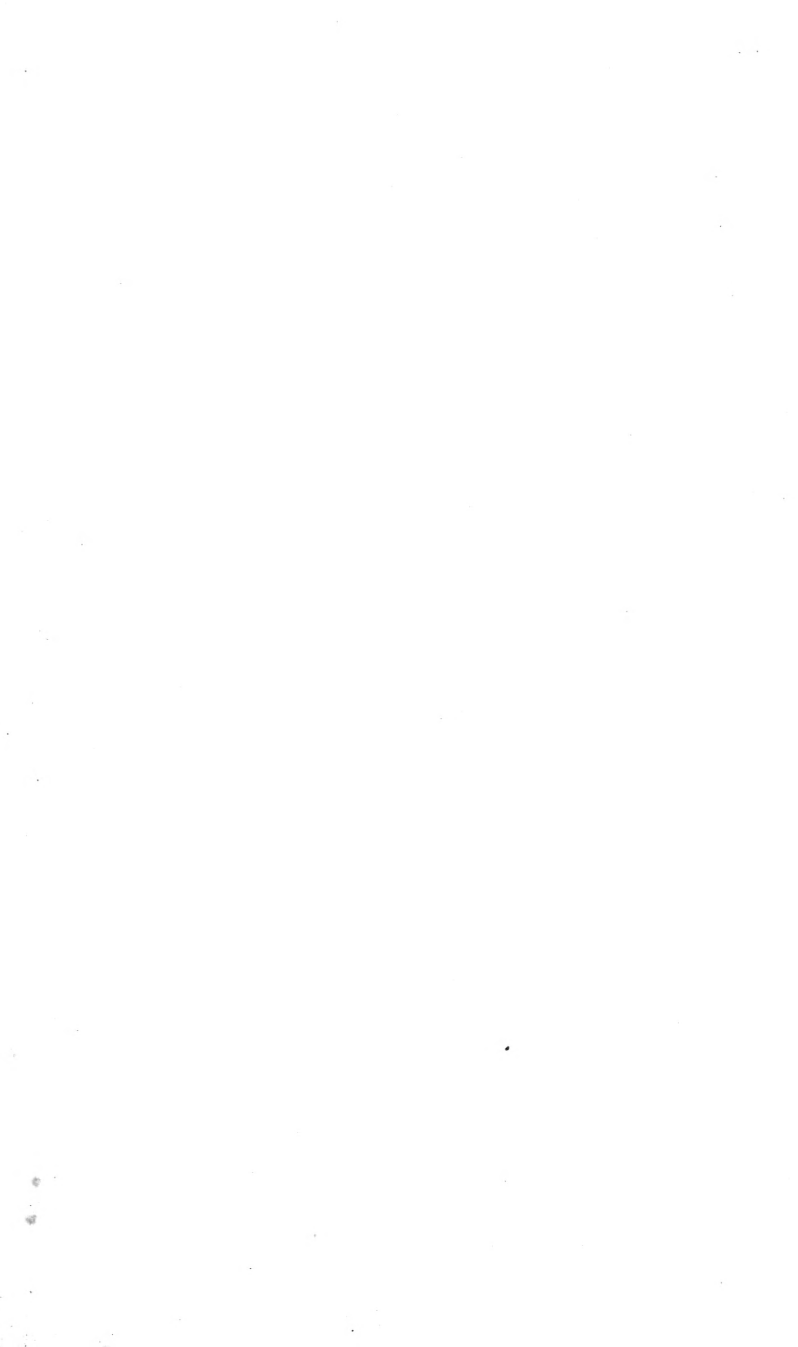


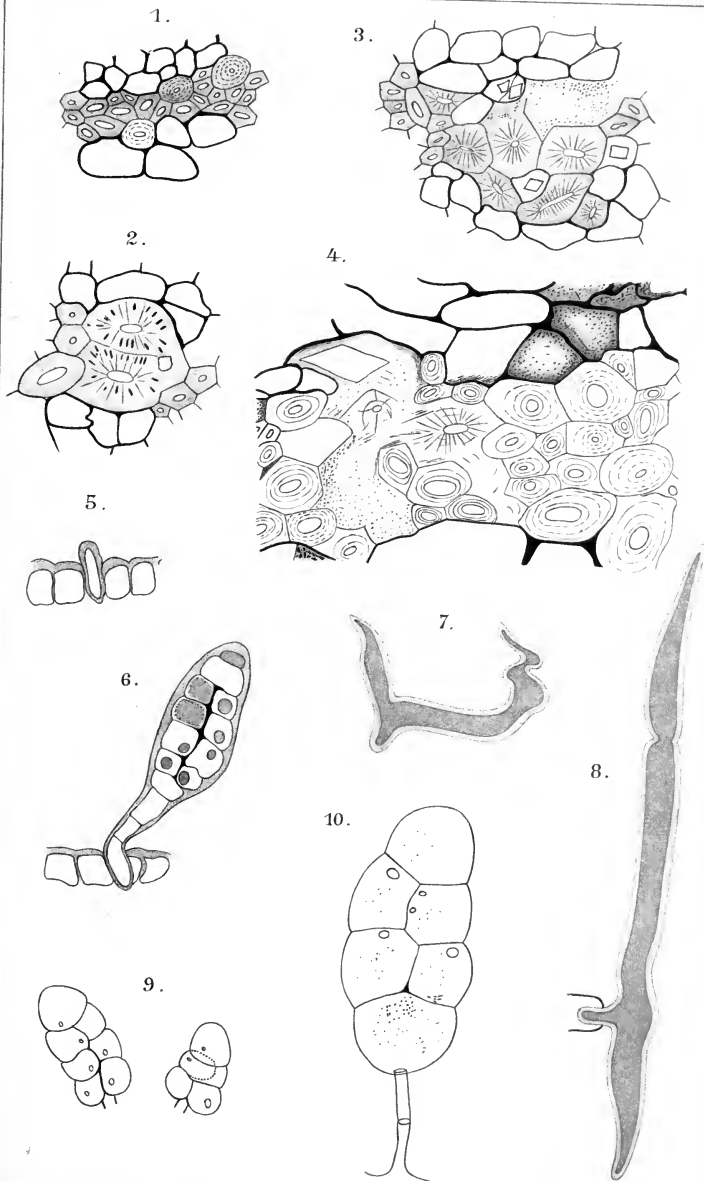












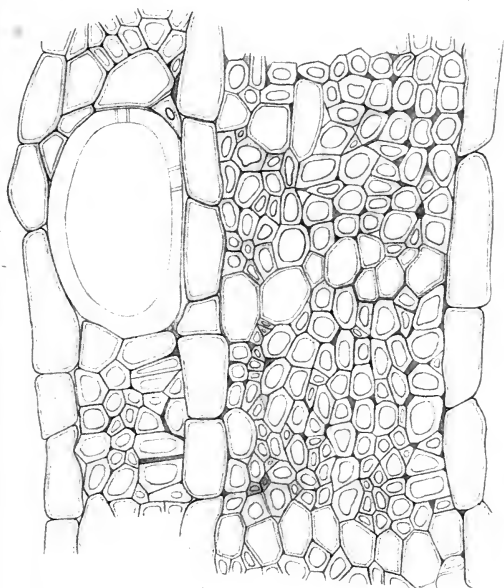
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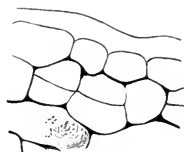
D. EBENUM.



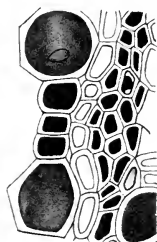
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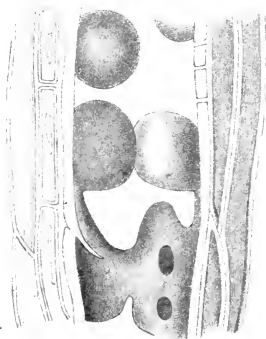
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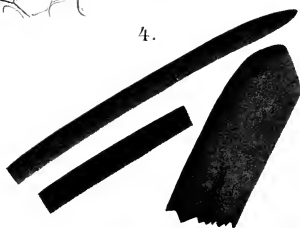
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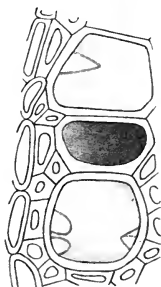
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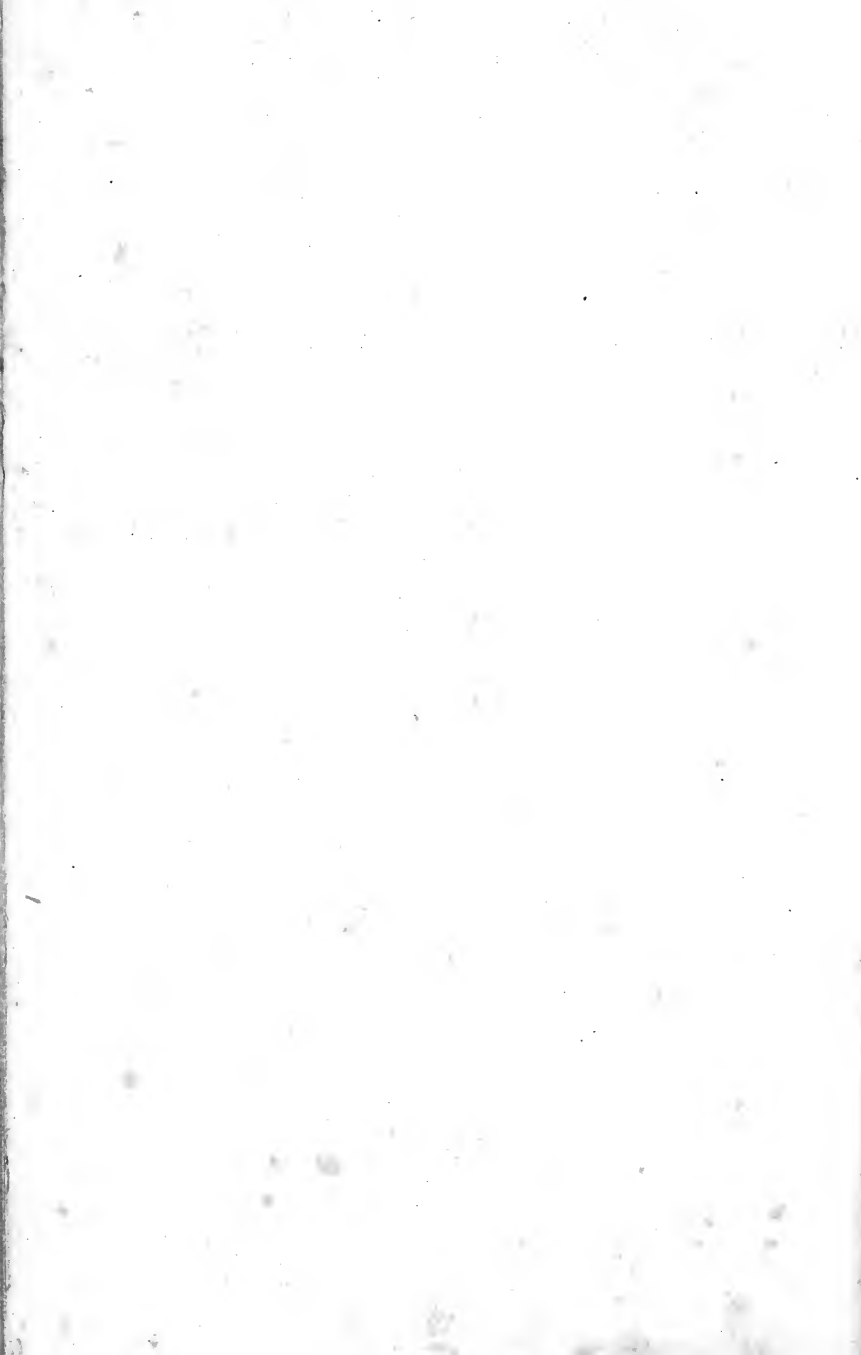


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5.







- acuta* 25-27, 61, 67, 71, 74, 75; 6.3 f. 10, 6.7 f. 8-14
- affinis* 6, 17, 38, 50, 62-64, 65, 69, 71, 74, 75; 6.1 f. 3, 6.10 f. 1-6
- attenuata* 22-25, 27, 67, 71, 74, 76; 6.2 f. 10, 6.11 f. 10-15  
*altida* (var) 10
- crumenata* 9, 65-67, 69, 71, 74, 75, 77, 78; 6.4 f. 14, 6.8 f. 1-5,  
*dodecandra* 13 6.18 f. 6
- Ebenum* 2, 6, 14-19, 25, 29, 38, 39, 40, 44, 45, 46, 51, 68, 69,  
 74, 76, 77, 78; 6.4 f. 15, 6.13 f. 1-8, 6.18 f. 8, 6.19, 6.20.
- Embryophum* 2, 6-10, 16, 30, 61, 67, 70, 75, 77, 78; 6.5 f. 20, 6.9,  
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 6.5 f. 18
- hirsuta* 2, 47-49, 61, 69, 71, 74, 77; 6.1 f. 2, 6.15 f. 6-12
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- Moonii* 2, 27, 38, 47, 48, 59, 59-62, 68, 71, 74, 76;  
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- Toposia* 10-14, 35, 40, 43, 68, 74, 75, 77; 6.3 f. 12, 6.10 f. 7-10,  
 6.17 f. 4





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